POWER SYSTEM COMMUNICATIONS:

Guide Specification for Microwave Communications System

REA BULLETIN 66-11

RURAL ELECTRIFICATION ADMINISTRATION • U.S. DEPARTMENT OF AGRICULTURE

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FOREWORD

This Guide Specification has been developed to acquaint the REA Borrowers and their consulting engineers with the essential elements of a properly prepared specification for the procurement of a Microwave Communication System. It is not intended to be mandatory in structure but rather, it should be used as a tutorial tool and guide in determining what is needed.

It is incumbent upon the user to add, delete and modify as appropriate for the particular system to be procured in conjunction with specific Borrowers' requirements.

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International System of Units

In December 1975, Congress passed the "Metric Conversion Act of 1975." This Act declares it to be the policy of the United States to plan and coordinate the use of the metric system.

The metric system, designated as the International System of Units (SI), is presently used by most countries of the world. The system is a modern version of the meter, kilogram, second, ampere (MKSA) system which has been in use for years in various parts of the world.

To promote greater familiarization of the metric system in anticipation of the U.S. converting to the system, REA is including metric units in its publications. This bulletin has, therefore, been prepared with the International System of Units (SI) obtained from ANSI Z 210-1976 - Metric Practice. Approximately equivalent Customary Units are also included to permit ease in reading and usage, and to provide a comparison between the two systems.

1.0 USE OF THIS GUIDE SPECIFICATION

1.1 Purpose

The intent of this bulletin is to provide an insight into the basic content requirements for the preparation of a sound, meaningful, and effective system design, engineering, and procurement specification for a Microwave Communication System.

The Guide Specification is not intended as the solution for total system specification preparation; it is as the title suggests, an aid to those Borrowers who find it necessary to establish definitive specifications to be used by potential bidders. It is emphasized that the bulletin is not directive in nature; rather, its information and its purpose is to aid and supplement that information already available to Borrowers. In this regard, where the word "shall" appears, it is intended to represent the Borrower's expression to the potential bidder.

1.2 Scope

The Guide Specification covers each of the elements potentially requiring contractor assistance in the establishment of a Microwave Communication System. This total system coverage permits the Borrower to use all or part of the content, dependent on support required. In addition, to covering the various inter-related system elements, the guide provides methods for obtaining contractor or consultant response to Borrower requirements as well as technical specification outlines. This guide provides only the framework for a professional and effective specification, but does not obviate the need for definitive engineering data and professional engineering effort. Indeed, this guide is not intended to be a substitute for thorough system planning and detailed engineering and design. Users of this bulletin must recognize that a thorough knowledge of system requirements must be attained before the bulletin is applied and that this knowledge is a product of adequate analysis and engineering effort. The scope of these activities are not explicitly addressed but their necessity is presumed to be understood.

1.3 Application

As earlier indicated, the contents of the bulletin are designed to permit their use in whole or in part. The solicitation instructions and attendant data (Sections 2.0, 3.0 and 4.0) are pertinent to interface with potential bidders and/or with consulting engineers as requirements dictate. In effect, the bulletin content permits a "cut and paste" capability for initial preparation of the system specification framework. The word "framework" is used advisedly to emphasize the essentiality of engineering input to the final package.

Users of this bulletin are advised to be alert to the impact a parameter specified at one point in the system may have on a parameter value at another point in the system. Borrower Engineers or Consulting Engineers are the obvious source of the data necessary to fill the blanks. The fill data is the critical information which will insure that each element of the total system meets the parameters essential to system realization, construction, operation, performance, continuity, and maintenance. Firm, definitive data in the basic specification will insure that eventual contractors are technically and legally responsible for the desired results. Delays in system completion caused by insufficient or ambiguous data and the attendant discussions or renegotiations with bidders or eventual contractors, can be avoided by thorough and professional preparation of the specification. It is reiterated that the Guide Specification is only as valuable as the engineering input to the specification. Proper use and application will greatly aid the Borrower in the timely development of a Microwave Communication System Specification, and serve to expedite any review and approval that may be required of the specification by the Rural Electrification Administration.

2.0 SOLICITATION INSTRUCTIONS AND NOTICE TO OFFERORS

2.1 You are invited to submit to (Cooperative Name) _____ (hereafter called the "Purchaser") your proposal for the provision and delivery, F.O.B., to the locations indicated, to include installation of equipment and materials specified, which are to be part of the project known as the _____ Microwave Communications System, to be financed and accomplished via a financing agreement between the Purchaser and the United States of America (hereafter called the "Government") executed by the Administrator of the Rural Electrification Administration (hereafter called the "Administrator").

Sealed Proposals, to include separate Cost Proposals, will be submitted as follows prior to _____ p.m., local time, (Date) _____.

Original and _____ copies to:

Copy to:

Proposals received or postmarked after the specified time and date shall be considered as "Non Responsive" and will not be considered unless:

- It was sent by registered or certified mail no later than the _____ calendar day prior to the date specified for receipt of offers (e.g., an offer submitted in response to this solicitation must have been mailed prior to _____ or earlier)

Acceptable evidence, as establishing proof of mailing shall be the U.S. Postal Service postmark on the wrapper, or Post Office Receipt.

2.2 Any Sub-Contractor or Material Supplier furnishing either equipment, materials or services under this project to a Prime Contractor must obtain any drawings, specifications or other documents relating to this project from its respective Prime Contractor and not from the Purchaser.

2.3 All proposals, together with other supporting documents, must be submitted on the forms furnished by the Purchaser, delivered in sealed envelopes, addressed as indicated under Paragraph 2.1 supra, with the name and address of the Offeror clearly indicated on the outside envelope containing the proposal.

Proposals must be submitted in conformance with these specifications. Should an Offeror desire to propose alternate equipment, methods in lieu of those contained in the specifications, they shall be clearly defined, and as proposed, satisfy the project requirements, and be submitted as an alternate to the basic specifications. All costs associated with an Alternate Proposal, shall be clearly defined, and furnished separate from those submitted for the basic specification requirements.

Any deviations, exceptions, or clarifications not treated in this manner shall be deemed non-compliant, and will not be considered.

2.4 The Offeror shall furnish with his proposal a complete set of specifications and typical drawings, including dimensions, design calculations and data, installation and maintenance instructions, operating characteristics, and such other information as is required to enable a thorough understanding of the equipment proposed to be furnished.

Unnecessarily elaborate brochures or other presentations beyond that sufficient to present a complete and effective proposal are not desired.

Elaborate art work, expensive paper and bindings, or other expensive visual presentation aids are neither necessary, nor wanted.

2.5 Specific information to be submitted with an Offeror's proposal shall consist of the following:

- Radio path and equipment availability and reliability calculations
- Comprehensive description of the test methods and procedures for factory and field system tests
- A project schedule showing work flow and all major items of work, emphasizing critical project items
- Appendix A, Radio Equipment Design Data
- Appendix B, Site Survey and Data Summary Sheets
- Appendix C, Link Data/Design Summary Worksheets

- List of critical and recommended spare parts for all items of equipment furnished, to include unit pieces

- List of required or recommended test equipment, to include unit pieces

- Listing of systems of similar design, complexity and operation previously furnished and installed by the Offeror, with names of organizations or persons the Purchaser may contact relative to the same

2.6 Prior to the submission of the proposal, the Offeror shall make and shall be deemed to have made a careful examination of the plans and specifications and forms of equipment contract on file in the office of the Purchaser and with the Engineer, and all other matters that may affect the cost and the time of completion of the work.

2.7 Within _____ days of receipt of this request for proposals, all perspective Offerors shall notify the Purchaser of their intent to bid. This notice shall be addressed to:

If desired by an Offeror, arrangements for a pre-submission meeting with the Purchaser will be made, to meet at the above location for discussion in reference to these specifications.

2.8 All proposals shall be signed by an individual authorized to bind the Offeror, and shall contain a statement that the proposal and Cost Quotations are valid for a period of not less than _____ days after the closing date to provide for proposal evaluation and resolution.

2.9 Any items which are clearly necessary for satisfactory performance shall be considered as part of the contract even though not directly specified. Such items should be noted by the Offeror and included in his proposal response.

2.10 Within _____ days after notice of award is given to the successful Contractor, a conference will be held in the office of the Purchaser for the purpose of discussing the details of the system equipment to be furnished and the schedule and manner in which the manufacturer's drawings are to be prepared and submitted. The Offeror shall have present at this meeting, the project engineer responsible for this project.

2.11 Any exception to those specifications must be clearly indicated by the Offeror using the following format:

a. Paragraph number

b. Exception taken and reason

c. Suppliers recommendations, substitution, or alternative

2.12 The contract, when executed, shall be deemed to include the entire agreement between the parties thereto, and the Offeror shall not claim any modification thereof, resulting from any representation or promise made at any time, by an officer, agent, or employee of the Purchaser or by any other person.

The Purchaser reserves the right to reject any or all proposals.

_____
(Cooperative Name)

_____ BY: _____
DATE

3.0 CONTRACT FORMS

The appropriate REA standard contract forms should be used. Usually, these forms will adequately express the intent of the parties to the contract. However, some modification of the standard form may be required in order to obtain the detailed description of services and work needed for a specific undertaking. When contemplating such changes, care should be exercised to prevent those changes from relieving the contractor of any of the responsibilities required of the REA standard form.

4.0 SCOPE OF PROJECT

This section should provide the qualitative information about the project that places it in clear perspective and, together with the detailed specifications, leads to as complete an understanding of the mission to be accomplished as practicable. This information should be in the form of a comprehensive summary that provides a general overview of the system, its objectives and requirements, equipment to be supplied, and a clear indication of the system's size and complexity. Information supplied should be concise, but, at the same time, in sufficient depth to ensure the quality of bids to be received.

Clear functional information about the system should be included. Uncertainty about the functional requirements can translate into additional system costs because increased flexibility must be designed into the system. While flexibility may be desirable if it can be obtained at little cost, it is often costly in terms of available resources and obtained at the expense of other valuable features. Functional information about the system should include terminal and repeater locations, spur branching points, direction of information flow and the type of information to be transmitted, channel types and quality, compatibility with existing equipment and services, and capability for expansion.

5.0 MICROWAVE SYSTEM PERFORMANCE

5.1 General

The design of the radio frequency, multiplexing, termination, and signaling equipment shall meet the requirements set forth herein.

The ___ GHz microwave radios shall operate in a nominal _____ GHz frequency spectrum and shall be configured for ____ channel full duplex operation as specified herein.

5.2 Fade Margins

Each path of the system shall be designed to provide a ____ db fade margin introduced in the path for the noisiest derived channel.

Field measurements of all paths shall be performed by the Contractor and shall be witnessed by Purchaser to verify their compliance with the Contractor's calculated fade margins.

5.3 Path Criteria

The system may be configured for non-space diversity operation. However, if review of the supplied path profiles indicates that discrete "adverse" reflection points would occur, then space diversity is to be considered, with supporting propagation analysis to be provided as part of the Offeror's proposal.

Tower heights shall be verified for an effective earth radius of K=___ and a Fresnel zone clearance of _____. All submissions shall be based on tower heights as called for in the tower specification or data supplied by Purchaser, however, this does not relieve the Offeror of the responsibility to point out any errors noted.

5.4 Alignment and Equipment Safety Factor

Each Offeror shall specify equipment and alignment safety factors for each path in his calculations and shall not include any other variable measurement tolerances unless specifically delineated and compensated for by increase of the overall power budget.

5.5 Noise Performance

All Offerors shall quote guaranteed system noise performance consistent with the number of microwave and multiplex links and prescribed fade margins. Further, he shall provide the performance data sheets necessary (using those model sheets contained in Appendices "A", "B" and "C" to accomplish) as part of his proposal.

All formulas, and any conversion factors used shall also be included.

5.6 Path Calculations

Path calculations shall indicate antenna sizes, transmission line lengths, transmitter and receiver characteristics, losses, gains, received signal levels and fade margin. Each Offeror shall qualify all assumptions used as a basis for his path calculations.

Noise calculations shall show, on a per hop basis, the noise contribution for each of the following noise sources.

- Idle
- Thermal
- Intermodulation
- Total composite noise in the 4 KHz derived voice channel

5.7 Radio Baseband Requirements

5.7.1 End-to-End Requirements

The following radio baseband requirements shall be met, with all the Contractor-furnished RF equipment having been connected as designed into one system, and shall be measured between the radio baseband send terminals at the near-end, and the radio baseband received terminals at the far-end of the system.

Total radio system noise to include radio thermal, intrinsic, intermodulation and feeder echo noise on the system from _____ to _____ shall not exceed a median level of ___ dBrnc0 (____pWp0). Further, the total noise shall not exceed _____ pWp0 one-minute mean power for more than _____ of any month nor exceed _____ pW one-minute mean power for more than (LKm/2500) x 0.1% of any month. The antenna system shall provide not less than _____ dB return loss at the WG input flange when swept from _____ MHz to _____ MHz. To facilitate testing of sections of the system, the allowable radio noise shall be based upon the length of the section as a proportion of the total system length. Allowable noise shall not exceed _____ dBrnc0 per hop.

The fade margin for any hops shall be at least ____ dB at the point at which the S/N ratio, flat, reaches 30 dB.

5.7.2 Baseband Transmit and Receive Crosstalk

The radio baseband transmit and receive crosstalk shall be at least _____ dB minus 10 log N dB below the baseband test tone level. This requirement shall be met over the entire multiplex baseband spectrum. N equals the number of transmission paths including spurs.

5.7.3 Transmission Gain Stability

The level of the radio baseband shall not deviate by more than plus or minus _____ dB from the normal operating level over the service conditions specified for at least 30 consecutive days.

6.0 RADIO SYSTEM

6.1 Microwave System

6.1.1 General

This specification provides the design objectives, and functional limits for the high performance Line of Sight, (LOS), microwave radio transmission system listed under "Scope of Project."

The RF equipment furnished shall comply with all applicable rules, regulations and standards of the F.C.C.

Each RF hop shall be engineered to handle the ultimate loading capacity of the RF equipment with respect to the maximum modulating signal, and highest modulating frequency, regardless of the initial specified number of channels. This capacity shall be stated.

A copy of the F.C.C. type acceptance on the radio system offered shall be furnished with the proposal.

Offerors shall furnish the name and address of at least three users of the RF equipment proposed.

The RF equipment proposed shall be completely solid-state and of U.S. manufacture or meet "Buy America" requirements.

All RF equipment, order wire, fault alarm transmitter and multiplex shall be mounted in self-supporting ____ inch racks, not more than 7 feet high. The rack uprights shall be drilled and tapped for standard 1 3/4 inch vertical mounting spaces.

The successful Offeror shall develop at no additional cost, all information required for the filing of Federal Communication Commission (FCC) licenses. License applications shall be complete and ready for submittal to the FCC within 30 days after contract award.

6.1.2 Metering Facilities

The RF equipment supplied shall contain built-in metering and test point facilities for convenient determination of proper equipment operation. The metering facilities shall be such that the accuracy of adjustments shall meet or exceed that required in the proper alignment of the equipment, and shall provide, as a minimum, measurement or monitoring of the following:

- Transmitter Power and Frequency
- Transmission Pilot Level and AFC
- Transmitter Forward and Reflected Power
- Receiver LO Drive Level, and AGC
- Receiver Discriminator Voltage, and Squelch
- Receiver Pilot Level, and IF Amplifier Voltage
- Baseband Levels
- Power Supply Voltages

Dust covers shall be provided for all equipment.

Subsystem alarm lamps shall be utilized and shall be visible when covers are in place.

Test points shall be conveniently accessible on the equipment and all adjustments that are required for the maintenance and alignment purposes shall be likewise accessible.

Control and test points shall be clearly marked, and shall agree with information and drawings supplied for operation and system maintenance.

Offerors shall furnish a minimum of ___ sets of operation and maintenance manuals for the RF equipment proposed.

6.1.3 System Operational Conditions

Operational Temperature Range	____ C to ____ C
Humidity	____ to _____ Non-Condensing
Altitude	_____ feet AMSL maximum
Duty Cycle	Continuous

6.1.4 Power Supply

Nominal Voltage	_____ VDC
Operating Voltage	_____ VDC to _____ VDC
Ripple Voltage	_____ mV rms ripple with positive terminal grounded

The power supplies furnished shall be of completely solid-state design and furnish regulated output voltage to the RF equipment. Separate power supplies shall be provided for each transmitter-receiver combination. Offeror shall state whether a separate power supply unit is required for sensing circuits.

A short circuit applied to the power supply output terminals shall not cause any power supply component failure, other than fuses. Reverse battery protection shall be provided such that reverse polarity applied to the input terminals shall not cause a component failure, other than fuses. Power supply units requiring no periodic field maintenance adjustments are preferred.

The power supplies shall operate with the primary supply input conditions specified above. Offeror shall include equipment current drain per site on a battery and charger calculation sheets.

All high-voltage contacts and circuit wiring shall be shielded to protect against accidental contact, and all shall be conspicuously labeled. All condensers shall have a discharge path so as not to retain a charge greater than ____ volts ____ seconds after power is removed.

The equipment shall be adequately protected against shorts and overloads of such nature as to cause damage. Fuses incorporating thermal delay to prevent outages due to momentary overloads not of a nature to cause damage shall be used. Fuses protecting solid state circuitry shall be of a quick-acting type. Each transmitter and receiver shall be individually fused with one or more alarm indicating fuses.

6.1.5 Modulation Technique

Frequency Modulation (FM).

6.1.6 Frequency Range

The system furnished shall be a ___ GHz system.

6.1.7 Channelization

The initial system will include ___ channels, but provisions for future expansion shall be provided to expand the system to ___ channels.

6.1.8 Emission Designator

Narrowband radio shall be ____ F9.

6.1.9 Pre-emphasis/De-emphasis

Pre-emphasis/De-emphasis shall be provided for ____ channel loading as standard equipment at all sites having multiplex drops.

6.1.10 Noise Power Ratio

Intermodulation acceptance test measurements shall be made in the factory using CCIR noise loading techniques, with emphasis at ____ channel loading. The equipment Noise Power Radio (NPR) shall be equal or better than ___ dB measured back to back at a received level of ____ dBm.

6.1.11 Return Loss

The equipment supplied shall have a minimum return loss of ____ dB when measured from ____ KHz to ____ KHz.

6.1.12 Frequency Response

The___GHz equipment supplied shall have a continuous baseband and frequency response flat to within _____ dB from ___ KHz to ____ KHz, and ____ to ____ dB from ____ Hz to ____ KHz. The baseband frequency response shall be measured between baseband input and output terminals over a single hop.

6.1.13 Level Stability

The stability of the baseband shall be such that the level of the signal delivered at the receiver baseband output terminals will not deviate by more than ____ dB per month per hop from the normal output level except during periods of fades in excess of the specified fade margin.

6.1.14 Baseband Regulation

The equipment supplied shall meet the specifications stated herein without the need for baseband regulation amplifiers.

6.1.15 Input and Output Impedance

The equipment supplied shall have ____ ohm unbalanced input and output impedance. Dual baseband inputs with ___ dB isolation shall be provided with reverse signal polarity for minimum system distortion. A block and level drawing containing information on the proposed baseband coupling shall be provided with the Offeror's proposal.

6.1.16 Input and Output Levels

The equipment supplied shall be designed to operate with ____ SSBSC voice channels with minimum input per channel test tone levels consistent with the equipment supplied.

6.1.17 Equipment Isolation

The equipment supplied shall have ____ dB minimum crosstalk isolation between transmitter and receiver operating on the same path including all baseband decoupling equipment.

6.1.18 Sensing Pilot

The equipment supplied shall utilize a per hop, sensing pilot. The sensing pilot must be either above or below the usable information baseband. Offeror shall state per hop pilot frequency supplied.

6.1.19 Transmitter

The transmitter shall be completely solid-state. All solid-state components shall be conservatively rated and have proven experience, relative to component reliability. Exotic or unproven components are not acceptable. Where component replacement is possible, preference will be given to that design that incorporates the most efficient, low cost components.

6.1.19.1 Transmitter

The equipment supplied shall have a transmitter frequency stability equal to or better than _____ over the temperature range of ____ C to _____ C.

6.1.19.2 Carrier Generation--Shall be crystal controlled.

6.1.19.3 Transmitter Baseband Levels
Adjustable for inputs from ___ dBm to ___ dBm.

6.1.19.4 Transmitter Output Power--Shall be ____ dBm.

6.1.20 Receiver

6.1.20.1 Noise Figure
The receiver noise figure shall be ____ dB maximum measured at the antenna port.

6.1.20.2 Image Rejection
The equipment supplied shall provide a minimum rejection of ____ dB at the image frequency, relative to the mid-band insertion loss.

6.1.20.3 IF Amplifier
Offerors shall state, if IF amplifier filters are optionally available to provide bandwidths different than that initially required, and for the associated per hop NPR and Equipment Gain values under conditions specified for each IF bandwidth.

6.1.20.4 Baseband Receiver Combiner
For those links operating in a diversity or hot standby configuration, the combiner shall not cause interruptions or transients which degrade the baseband signal. Level changes due to automatic combiner action shall not exceed ____ dB. There shall be no active components common to both RF basebands. The combiner shall permit normal system operation when either path in the combiner is disabled due to equipment failure or maintenance service. Alarm provision shall be provided in the combiner control to give an alarm until the combiner is restored to normal service. Any combining action, either manual or automatic, shall not affect transmission in the opposite direction. Each RF terminal shall be equipped with a visual to indicate normal operation of each receive channel and shall contain circuitry to prevent switching to a defective channel.

6.1.21 Fault Sensing
The equipment supplied shall contain fault sensing as standard equipment in the hot standby configuration. The fault sensing circuitry shall provide monitoring and alarm for failure of:

- Receiver carrier level
- Continuity of signal path through all receiver demodulation circuits
- Transmitter carrier level

6.1.22 Tuning, Alignment, and Metering

Tuning adjustments and test points for complete and accurate testing and alignment of the radio frequency, multiplexing, and terminating equipment shall be provided. All adjustment control and metering points shall be clearly labeled.

6.2 Orderwire Circuit

6.2.1 General

One orderwire assembly shall be provided at each location to provide party-line communications between all sites of the system. The panel shall be equipped with signaling, speaker, handset, telephone set jacks, and provisions for a 2-wire or 4-wire radio extension option. The orderwire assembly shall be applied directly to the microwave baseband, and it shall be completely independent of any other multiplex which might be used at the stations.

6.2.2 Frequency Response (V.F. reference to 1 kHz)

- 300 to 3400 Hz _____ dB, _____ dB
- 600 to 2400 Hz _____ dB
- 400 to 3000 Hz _____ dB, _____ dB

6.2.3 Impedance

Shall be 600 ohms, balanced.

6.2.4 Return Loss

Shall be ____ dB minimum - 4 wire.

6.2.5 Idle Noise

Shall be ____ dBrnc0 maximum.

6.2.6 Envelope Delay Distortion

Less than ____ microseconds (____ to ____ kHz).

6.2.7 Harmonic Distortion

Less than ____% 0 dMb0 at 1000 Hz.

6.2.8 Level Stability

Short term, _____ dB.

6.2.9 Longitudinal Balance

Shall be ____ dB minimum (____ to ____ Hz).

6.2.10 Speaker

Unit shall be equipped with local shelf-mounted speaker in addition to handset and headset. When handset is "on-hook" all voice transmission and tone signaling shall be audible on the local speaker.

6.2.11 Audio Signal-to-Noise

Audio signal-to-noise ratio shall be equal to or greater than ____ dB.

6.2.12 Crosstalk

Isolation between basebands of the service channel shall be greater than ____ dB.

6.2.13 Signaling

Each orderwire service channel shall be equipped with a signaling device of the party line type.

7.0 MICROWAVE ANTENNA SYSTEM

7.1 General

The microwave antenna system may be designed for space or non-space diversity operation as the requirements dictate. All antennas shall be tower mounted and all paths shall be direct antenna-to-antenna radiating. Connection to the radio and antenna may be by _____ inch jacketed, air dielectric, low VSWR, pressurized flexible line, foam dielectric/or waveguide. All antennas shall be low VSWR of the plane polarized type. All antennas, radomes, lines and antenna mounts shall be designed for ____ psf wind-loading and ____ inch radial, solid ice on all surfaces, in strict accordance with the latest edition of EIA Standards RS-195A and RS-222C. Path and antenna operation shall be in strict accordance with all FCC requirements. Exceptions to the above requirements should be stated explicitly and supported by detailed analysis.

7.2 Frequency Range

Antennas are to be used in the frequency range of _____ GHz.

7.3 Performance Characteristics

Offeror shall supply guaranteed performance characteristics for each type and size of antenna furnished. This information should include and be worst case.

- Gain at the bottom, mid-band and top of the frequency band in dB
- Beam width in degrees
- Front-to-back ratio in dB
- Voltage standing wave ratio (VSWR)

7.4 Radiation Pattern Envelope

Offeror shall supply the Purchaser with graphs of typical or worst case radiation pattern envelopes for each type and size of antenna supplied.

Offeror shall include guaranteed performance calculations with his proposal.

7.5 Deflections

Deflection not to exceed _____ degrees in _____ km per hour winds.

7.6 Fittings

All fittings shall be of the low VSWR type. RF equipment and fittings shall be the tuned type, with gas fittings, and compatible with dry nitrogen gas pressurization system, if required by the design.

The antenna input flange shall be of the _____ inch EIA standard.

7.7 Antenna Mounting

Vertical antenna mounts shall be included with the following mobility:

° Azimuth ± _____ degrees

° Elevation ± _____ degrees

Vertical antenna tilt mounts shall be included as an optional price to be used where required with the following mobility:

° Azimuth ± _____ degrees

° Elevation - _____ degrees to + _____ degrees

All mounts shall be hot-dipped galvanized steel or equivalent rust protection.

7.8 Pressurization System (As may be required)

A dry nitrogen pressurization system shall be used and shall consist of, but not limited to the following:

° All connections and fittings required for a complete pressurization system

° An adjustable pressure regulator

° A multiport manifold for pressurization of more than one transmission line at a site. This manifold must have at least one spare port for future expansion at each site

° Low pressure alarm indicator to be connected to the microwave alarm system

° 0 to 15 psi pressure gauge

° All required valves and tubing

° Nitrogen tank

7.9 Transmission Line System

7.9.1 The transmission line system from antennas to the radio shall constitute at least the following items:

° Low loss _____ inch air dielectric (or electrical equivalent) coaxial cable capable of being pressurized with dry nitrogen shall be quoted

° An interface connector from _____ inch coax to _____ inch EIA antenna flange for _____ GHz

- A tuneable connector ____ inch to Type ____ jack for ____ GHz
- Transmission line hangers and fasteners to be mounted at three foot intervals on the towers to provide support for the lines
- A grounding kit for ____ inch coax transmission line
- Wall feed through waveguide entry ports for buildings
- Any required jumper cables and accessories for a complete antenna and coax transmission line installation

7.9.2 The frequency range of the transmission line shall meet or exceed that specified for the antennas. The Offeror shall supply the Purchaser with all transmission line loss data and losses associated with all connectors and associated equipment.

7.10 Waveguide System

7.10.1 Waveguide

Standard high conductivity copper _____ waveguide of a type suitable for the frequency band of interest shall be used in all typical backbone repeater and terminal installations.

Attenuation shall not exceed _____dB/m ± ____% at the lowest operating frequency specified herein at a nominal temperature of _____°C.

7.10.2 Connectors

Connectors shall be brass and provide transition from elliptical waveguide to CMR137G contact flange interface at both the antenna and RF equipment ends. The equipment end connector shall be equipped with a pressure inlet.

One (1) low VSWR _____ cm flexible section shall be used at the feedline/equipment interface end as part of the permanent installation. An additional flexible section may be used as required at the antenna end for orientation purposes during the initial installation, but must be removed upon completion of the final installation if physical restrictions permit. In no case shall the use of flexible waveguide exceed two (2) sections of _____ m maximum length.

Flexible sections shall be silver plated brass or bronze and supply no more than _____ dB insertion loss and a maximum VSWR of _____ over the frequency range previously specified. Flexible sections shall be pressure sealed and covered with a protective neoprene jacket.

7.10.3 Installation

All ferrous metals used as part of the waveguide installation shall be hot-dipped galvanized or stainless steel. All screws, bolts, lockwashers and nuts shall be made from stainless steel or brass or hot-dipped galvanized in accordance with ASTM-153

Where used elliptical waveguide runs shall be continuous from end connector to end connector with a minimum amount of bends and no splices. Runs shall be of sufficient length to avoid the use of a flexible waveguide section exceeding ____ cm at the equipment end. Connectors and flanges shall be installed properly utilizing appropriate gaskets, sealent compound and alignment techniques to minimize mismatch and pressure leakage.

Hoisting grips shall be used at every ____ m when lifting the waveguide vertically along the tower. The top grip shall be left as a top hanger in the final installation. Waveguide hangers shall be spaced at intervals not to exceed _____ m and mounted to the tower angle members via a clamp type adaptor mount. Horizontal waveguide runs along the ice shield/waveguide bridge shall be supported at _____ m intervals via threaded rod type ceiling adaptor hangers. End supports on horizontal runs shall be within ____ m from each end.

Waveguide building entrance shall be made through a suitable feed-through flange equipped with rubber weathertight and weatherproof (wind, dust, moisture) boot.

The transmission line system shall be properly purged to displace all foreign particles and moisture.

7.10.4 Grounding

Each waveguide run shall be solidly grounded to the tower at the uppermost vertical hanger point, at the lowest vertical hanger point, and at approximately ____ m intervals along the vertical run. Solid connections shall be insured through the use of copper braid and tower connection lugs. The waveguide shall also be solidly connected to the tower ground system near the point of building entry.

7.10.5 Return Loss

Contractor shall ensure that the waveguide run terminated into the antenna presents a return loss of not less than ___ dB when measured at the mating flange across the operating frequency band specified.

7.11 Acceptance Testing

The Offeror shall perform all antenna waveguide and transmission line measurements necessary to provide an operable system. These measurements shall be conducted by qualified technicians.

The Offeror shall test the antenna system after installation. The tests shall include, but not be limited to the following:

- Swept Return Loss of Waveguide and Transmission Lines
  Each waveguide and transmission line run will be terminated and a swept return loss measurement performed as it is installed. The measurement will be performed over the entire operating band.

- Path Alignment
  After the antenna has been installed and properly secured for beam orientation, an electrical alignment will be made using link alignment equipment.

- Swept Return Loss of the Antenna/Waveguide-Transmission Line System
  After the system has been aligned, the entire system including all transmission components will be measured with a swept loss system over the entire operating band. In the event that the system is to be left for further testing at a future date, the entire system will be pressurized.

- Integrity of Pressurized System
  After installation of the pressurization equipment and completion of the electrical testing, a pressurization test will be performed.

A copy of the results of all tests will be supplied to the Purchaser.

8.0 MULTIPLEX SYSTEM

8.1 General

This specification sets the minimum performance requirements for carrier multiplex equipment (MUX). Unless otherwise specified, characteristics apply to two multiplex terminals connected back to back on the HF line.

8.2 Design Features

8.2.1 The MUX equipment shall be of all solid state design except for the signaling and alarm relays.

8.2.2 Capacity, initially, shall be capable of handling up to ___ single sideband channels. Future requirements may dictate expansion to ___ channels over each route. Offerors shall consider and detail the requirements necessary to expand the MUX to a ___ channel operation.

8.2.3 Channel modems shall be mounted in standard EIA self-supporting racks not exceeding ____ m in height.

8.2.4 The system frequency plan shall comply with CCITT recommendations. If frequency plan does not comply, the Offeror shall explain plan in use. Modulation and sideband allocations are to be explained.

8.2.5 E&M signaling as may be required shall be built into or plugged into the channel modem. Offeror shall denote how frequency determing elements are connected to the channel modem. Any other signaling media offered shall be consistent with the technical specifications offered herein.

8.2.6 All performance specifications shall be met, with the equipment being powered from an unregulated dc source with up to ____ millivolts RMS ripple.

8.2.7 The channel transmitter shall include amplitude limiting as required.

8.2.8 Redundancy of active common channel elements and assoicated sensing equipment shall be detailed.

8.2.9 All power input circuits shall have reverse polarity protection.

8.2.10 Offeror shall state maximum channel loading capability for full channel complement.

8.2.11 The equipment shall be of modular construction with all modules and sub-modules being of the plug-in type. No soldering shall be required to add signaling options.

8.2.12 Expansion shall be accomplished by either plugging modules into pre-wired shelf spaces, or by adding shelves to existing racks, without need for reviewing or relocating existing equipment.

8.2.13 Offerors shall state the cost of adding a single channel associated with expansion operations.

8.2.14 Environmental Conditions

The performance specifications listed in this document shall be met under any combination of the following ambient conditions:

- Temperature - ____°C to + ____°C
- Humidity ____ to ____ % non-condensing
- Altitude Sea level to _____ meters AMSL

8.2.15 Ample test points, controls and indicators shall be provided to facilitate preventive and corrective maintenance with standard test equipment. No unique tools or test items, except for a card or module extender shall be required.

8.2.16 All controls, test points, adjustments and operational circuits must be accessible from the front of the rack.

8.2.17 Individual channel alarm indication, visual bay alarm and contacts for remote alarm shall be provided.

8.3 Performance Parameters

8.3.1 Synchronization

Channels shall be synchronized with end-to-end zero frequency translation error.

8.3.2 Carrier Leak

Carrier leak shall not exceed ____ dBm0 except when a carrier is used for signaling or synchronization.

8.3.3 Crosstalk

Combined near-end, far-end, and adjacent crosstalk shall not exceed ___ dBrnc0 (___ dBm0).

8.3.4 Envelope Delay

Envelope delay shall meet circuit 3002 (C1, C2, etc.) conditioning requirements.

8.3.5 Return Loss

8.3.5.1 Voiceband

4 wire: ___ dB minimum 300 Hz to 3400 Hz
2 wire: ___ dB minimum

8.3.5.2 Baseband

Normal level: ___ dB minimum
High level: ___ dB minimum, ERL

8.3.6 Harmonic Distortion

Total harmonic distortion shall not exceed __% at 1KHz, 0 dBmO test tone of any frequency within the pass band.

8.3.7 Idle Noise

Idle noise shall not exceed __ dBrncO per channel and ____ channel loaded noise to ____ dBmO per channel shall not be more than ____ dBrncO.

8.3.8 Loaded Noise

Loaded noise for maximum loading of low density shall be explained.

8.3.9 Longitudinal Balance

Longitudinal balance shall be at least __ dB, 4-wire circuit and __ dB, 2-wire circuit.

8.3.10 Level Stability

Level stability shall not vary by more than ± _____ dB per month.

8.3.11 Phase Jitter

Phase jitter shall not exceed __ degrees peak-to-peak at a 1KHz test tone.

8.3.12 Signaling Distortion

Signaling distortion shall not exceed __% over a ± ___ dB operating level range with a 30% to 70% make-break ratio.

8.3.13 Signaling Pulse Rate

The signaling pulse rate shall be __ to __ pps.

8.3.14 Test Tone Levels

8.3.14.1 Voice band:

Transmit: 2-wire, __ to __ dBm (adjustable)
4-wire, __ dBm

Receive: 2-wire, __ to __ dBm (adjustable)
4-wire, __ to __ dBm (adjustable)

8.3.14.2 Baseband:

Transmit: ___ to ___ dBm (adjustable)
(___ to ___ channels)

Receive: ___ to ___ dBm (adjustable)
(___ to ___ channels)

8.3.15 Channel Frequency Response

300 Hz to 3400 Hz: ___ dB to ____ dB
600 Hz to 2400 Hz: _____ dB
(Referenced to 1KHz)

8.3.16 Impedance

8.3.16.1 Voiceband:

2-wire, 600 or 900 ohms, balanced
4-wire, 600 ohms, balanced

8.3.16.2 Baseband:

___ ohms

8.3.17 Power Requirements
-22 to -28 volts dc or -44 to -56 volts dc Offerors shall explain the method of converting a channel modem from one voltage to the other.

8.3.18 Overload Protection
Protection of multiplex equipment shall be explained by the Offeror in his proposal.

8.3.19 Signaling Options
Signaling options shall be listed and explained. The cost of the various signaling options shall be included as part of the proposal pricing.

8.3.20 Signaling
Signaling frequency shall be explained with options available and explanation to any limitations.

8.3.21 VF Levels

8.3.21.1 2-wire:

Send level: ___ dBm to ___ dBm
Receive level: ___ dBm to ___ dBm

8.3.21.2 4-wire:

Send level: ___ dBm
Receive level: ___ dBm to ____ dBm

8.3.22 Hybrids

Hybrid circuits required to convert 4-wire operation to 2-wire operation shall be equipped with a balance control and shall be of the transmission type.

8.3.23 Jackfields

Jackfields shall be provided for all channels. Jacks for each channel shall include:

- Channel mod tip and ring
- Equipment out tip and ring

8.3.24 Limiting

Offerors shall consider the requirement for limiters on the transmit side of the channel modem. Limiters, if used, shall have the following characteristics:

Apply a 1kHz test tone to the channel input at 0 dBm0. An increase at this tone level of ____ dB will cause the level at the modem output to increase ____ ± ____ dB. Increasing the input level to ____ dBm0, the output level shall not exceed ____ dBm0.

8.3.25 Terminating Options

The Offeror shall state the availability, cost, and/or modifications to the following terminating options:

- 2-wire, 600 ohm, no signaling
- 4-wire, 600 ohm, no signaling
- 2-wire, E&M signaling
- 4-wire, E&M signaling
- 2-wire, loop originating for FX phone extension, PABX end
- 2-wire, loop terminating for FX extension, equipped with idle line termination, AC ringdown and ringdown trip
- 4-wire radio base station control (DC)
- 2-wire/4-wire, E&M signaling, PABX tie trunk

9.0 ALARM SYSTEM

9.1 General

Offerors shall furnish all equipment necessary to make operational an alarm system for the purpose of monitoring the microwave and _____ radio equipment. Each site shall be equipped with an alarm transmission system to transmit the system status at that station to a master station located in the headquarters communications facility.

9.2 Design

The alarm system requirement shall be of all solid state design. It may either be of the continuously monitoring type or the interrogating type. Fail safe operation shall be provided. Circuitry shall be mounted on plug-in cards or modules mounted in equipment shelves or card cages.

9.3 Remote Requirements

Remote terminals shall be capable of receiving alarm inputs for normally open, normally closed, supply voltage, or ground conditions.

The remote unit shall have capability of providing control outputs by addition of equipment only. Control outputs are not to be included in the initial system configuration.

Each remote terminal shall be equipped with the following features:

- Local display to provide front panel indication of each alarm input
- Alarm memory to assure that all alarms lasting greater than _____ ms will be transmitted by the remote unit

Remote terminals shall operate on a nominal -24 volt DC or -48 volt DC. Option shall be field selectable and shall be selected on the basis of the station power source.

9.3.1 The remote alarm unit shall be located in the unattended sites, and must be capable of continuous operation without corrective maintenance under the following conditions:

- Operating Temperature Range ___°C to ___°C
- Ambient Humidity ___% to ___% non-condensing
- Power ___ VDC to ___ VDC with ___ MV p-p ripple

9.3.2 Amplifiers employed in the transmit and receive paths shall be adjustable to control the baseband tone levels within the specification limits of the test tone levels established for the system.

9.3.3 Each remote unit shall be equipped with a baseband tone bridging scheme to permit multiplexing of tone channels directly to the baseband without the use of voice multiplex equipment.

9.3.4 The remote alarm units shall operate from a ___ VDC power source and transmit the status of a minimum of ____ alarm points. The remote alarm units shall be easily expandable to _____ alarm points. Offerors shall detail this expansion capability in his proposal.

9.3.5 Each remote alarm transmitter shall be wired to transmit the following alarms initially:

- Radio receiver failure (all major alarms connected in parallel)
- Radio transmitter failure (all major alarms connected in parallel)
- Building Hi/Lo temperature
- Loss of AC power
- Loss of battery charger DC output
- Hi/Lo dc voltage (paralleled)
- Illegal entry of radio building
- VHF or UHF radio failure
- Tower beacon lights failure
- Transmission line pressure failure

9.3.6 The transmission tone equipment used shall utilize a transmit and receive frequency in the ___ to ___ KHz band.

9.4 Master Requirements

The master station shall continuously interrogate in a sequential manner each of the remote stations, and report normal or off-normal conditions. The master station shall, as a minimum, include or display the following:

- Change of status
- Alarm status of each parameter interrogated
- Alarm disable to silence alarms from stations having intermittent alarms
- Indicate major or minor alarm

9.4.1 The master alarm unit and associated equipment must be capable of continuous operation without corrective maintenance under the following conditions:

° Operating Temperature Range ____°C to ____°C

° Ambient Humidity ____% to ____% non-condensing

° Power ____ VDC to ____ VDC with ____ MV p-p ripple

9.4.2 Transmit and receive terminals must have at least ___ dB isolation. Spurious tones and harmonics that may be generated by either the transmit or receive equipment must be less than ____ dBmO outside of the operating bandwidth.

9.4.3 The master alarm unit shall operate from a ____ VDC power source.

The alarm equipment will be connected to microwave baseband and operate in the ___ to ___ kHz frequency band. The transmit and receive levels and the impedances shall be compatible with the equipment proposed.

9.4.4 The master station, as installed, shall:

° Be capable of indicating the site from which the alarm is being sent, as well as the specific alarm nature, without the necessity for the operator to depress any decode or select button

° Have both visual and audible alarms

° Display the identity of any site which has transmitted a change of status signal since the last system check

° Display the identity of stations which are in failure due to tone transmitter failure or no modulation of the tone transmitter

° When manually selected, display the status of each of the alarm points at each remote site

° Provide a visual indication of code check confirmation from the selected station

° Provide an audible alarm indication that may be silenced or acknowledged from a location other than the master station cabinet

° Provide a method to allow audible alarms to be selectively silenced on one or more faults without affecting any other alarm(s) that may occur before a particular alarm is corrected

9.5 Alarm Security

Alarm tones shall be coded to prevent false reporting. The coding security scheme shall be explained in detail by the Offeror.

9.6 Indicators

A means shall be provided for checking visual alarms without removing indicators from the master or remote units.

9.7 Master Station Printer

A master station printer shall be furnished and installed to provide a hard copy record of all changes of alarm status occurring in the system. Printer shall have ASCII output ports.

10.0 SITE BUILDINGS AND FACILITIES

10.1 General

This specification covers the requirements for the buildings to be supplied and erected for the (Name of Cooperative) _____ Communications System.

All buildings supplied shall be of a _____ type, meeting or exceeding the requirements of this specification.

Buildings shall be installed at the sites specified, on firm and stable foundations, incorporate non-porous wall and roof sections, to preclude capillary action, and shall be so designed, and so constructed to provide a minimum useful life period of 20 years, without need for major maintenance actions. Offerors shall indicate building warranties and/or guarantees in their proposal response.

All buildings furnished shall be of the same size, configuration, and construction.

10.2 Specific Conditions

The buildings to be furnished under this specification shall be designed for the following conditions, and shall not be subject to damage under any individual or combination of conditions.

- ° Winds to _____ MPH
- ° Ambient temperature of ___° to ___°C
- ° Ambient humidity from 0 to _____ percent

10.3 Construction

Under the service conditions listed in 10.2 above, all buildings furnished shall be:

10.3.1 Provided with a smooth, water, air and dust tight homogeneous non-combustible external surface that will not clip, or delaminate under impact of hail or blowing rock during extreme weather conditions. The outside surface shall not contain any unfused joints or penetrations except at doors, air intake or exhaust openings, power service entrance and waveguide ports, and these openings shall be water-tight to the degree that hurricane force winds will not drive moisture around frames or through seals. If fiberglass construction is used, the outside surfaces shall be covered with a gel coating that will prevent undue weather cracking and surface deterioration.

10.3.2 Constructed in such a manner that the total heat transfer through walls, roof, floor and doors will provide a maximum heat transfer factor of _____ BTU/hr/m^2°C temperature difference.

10.3.3 Erected on a concrete foundation, with a concrete floor, and when set in place, satisfy the service conditions herein specified.

10.3.4 Provided with a finished floor of vinyl asbestos (or other comparable finish) base floor covering and capable of adequately supporting live loads of _____ Kg/m^2. The floor shall be so constructed as to provide a holding depth of at least _____ cm for equipment anchoring devices.

10.3.5 Provided with a roof capable of supporting adequately a live load of ___ Kg/m^2.

10.3.6 Inside walls shall be smooth-surfaced and light-colored to permit maximum utilization of available light, and shall not be subject to damage under normal operational activities.

10.3.7 Buildings shall have a minimum inside dimension of ___ by ___ m, with a minimum inside floor-to-ceiling height of ___ m. Major equipment items shall be positioned as per a building floor plan to be designed by Offeror.

10.3.8 The building door shall be fitted with double doors on one face, and shall be located on building floor plan developed by Offeror. Door hinges shall be heavy duty and corrosion resistant, capable of holding seals tight under specified conditions. Door seals should be one piece, RF type for effective seal and to preclude EMI. The doors shall be equipped with a three point latch. The doors shall be provided with adequate tamper proof locking devices. The integrity of the door seal shall not be affected by the fastners. The door shall have a door stop and shall be provided with a device to hold the door closed while working inside. Means shall be provided to open the door from the inside. The door shall be flanged ___ cm completely around the door to ensure that hurricane force winds will not drive water or dust into building past door seal.

10.3.9 The door shall be equipped with a device to lock the door in the open position in order to prevent the door from being damaged by gusting wind. The door shall be equipped with a switch to provide contact closure when the door is open. Wiring from the switch shall be run through conduit to a position over the rack where fault-reporting equipment is located.

10.3.10 All exterior items being installed shall be sealed with G.E. Silicone Sealer, No. SE-1209, or approved equal.

10.4 Environmental Conditions

10.4.1 The building shall be equipped with a forced air electric heater, ventilation fan and air conditioner capable of maintaining the inside temperature under operating conditions, plus sensible and latent heat gain from people, at ___°C ± ___°C. These conditions to be met with service conditions previously specified in paragraph 10.2. No ventilation fan and the air conditioner shall be wired in such a way as to allow the simultaneous operation of both units. The ventilation fan shall be dampened against back thrust. Air intakes and exhausts shall be equipped with roden screens and an air filter.

10.4.2 Lighting shall be installed within the buildings, to provide ___ m candles at a height of plus ___ meters from finished floor. All components used shall be quality grade industrial lighting fixtures.

10.4.3 A thermostat shall be provided. An alarm consisting of a contact closure at room temperatures of more than ___°C and less than ___°C shall be provided, and connected to system alarm facilities.

10.5 Electrical Facilities

The Offeror shall supply a complete working electrical system for the building. The work shall include the delivery to the site of all labor, equipment and the performance of operations required for the installation of the complete electrical system.

10.5.1 The Offeror shall supply the following minimum equipment:

- 1 - ___ breaker ac distribution cabinet with ___ ampere main breaker
- 1 - ___ position ___ pole dc distribution fuse cabinet
- 1 - Air conditioner (floor mounted) EER Rating 10.0 minimum
- 1 - Ventilation fan with thermostat control
- 1 - Forced air electric heater
- _ - 125 volt ac convenience outlets
- _ - ___ watt incandescent bulb light fixtures
- 1 - Set air intake louvered vanes with fiberglass filter and bird - rodent screen
- 1 - Set of waveguide entrance ports, located as per design plan
- Cable ducts as required by floor plan design

- _____ (or approved equal) thermostat to be used as a radio building Hi/Lo temperature alarm

10.5.2 All equipment and materials furnished and installed shall be new in condition, and of the highest quality, and shall be standard products of manufacturers regularly engaged in the production of such equipment and materials, shall be the latest standard design, and shall bear the Underwriter's Laboratories Seal of Approval where applicable.

10.5.3 Installation shall comply with the latest National Electrical Code, anything in these specifications or drawings to the contrary notwithstanding.

10.5.4 Purchaser will supply electrical service to the building. This service will be 120/240 V, single phase, 3 wire, 60 Hz, _____ A capacity.

10.5.5 The Offeror shall supply the building with an underground service in accordance with Article 230-24 (b) of the National Electrical Code.

10.5.6 A ____ cm rigid galvanized conduit, shall be used for the service entrance conductors and shall be firmly fixed to the building inside wall for attachment to ac distribution panel. Further, the conduit shall be sealed against moisture at its entry to the building.

10.5.7 The main power panel shall have a minimum rating of _____ A, 120/240 VAC. It shall be furnished with properly sized circuit breakers for the loads to be supplied.

10.5.8 Branch circuits shall be so arranged that the 120/240 VAC service to the building is balanced, resulting in less than ____ A neutral current.

10.5.9 All interior building wiring shall be in rigid electrical conduit or electrical metallic tubing. Articles 346 and 348 of the National Electrical Code shall apply.

10.5.10 Flexible metal conduit used shall be as covered by Article 350 of the National Electrical Code. Runs of flexible metallic tubing shall be as short as practical and shall terminate in proper connectors.

10.5.11 All conductors shall be properly sized for the load that they supply, but, shall be no smaller than #12 AWG. Conductors shall be copper, type THHN. Stranded conductors may be used when run in flexible metallic conduit.

10.5.12 Stranded wire shall use approved pressure connectors for splices and terminations.

10.5.13 Where wire nuts are used for splicing conductors, they shall be properly sized, preinsulated type spring connectors.

10.5.14 Conductors shall be continuous from outlet to outlet. Splices shall be made within outlet boxes or junction boxes only.

10.5.15 Duplex outlets shall be ___A, 125V, 3-wire grounding, heavy duty type.

10.5.16 The entire electrical system shall be checked after installation at the site and adjustments made to provide a proper working system.

10.5.17 A minimum of _____ convenience outlets shall be provided, typically located at ____ meter intervals on each wall, except where battery bank is located. Outlets shall be located in accordance with the design floor plan.

10.5.18 All wiring and cabling to the microwave equipment racks shall be installed in an overhead raceways. The wiring will be supplied and connected by the Contractor as will the raceways.

10.5.19 All breakers, distribution centers, contactors, etc., shall be contained in NEMA Type 1 enclosures, and manufactured by Square D, General Electric, or approved equal.

10.5.20 All equipment and hardware installed in the building shall be done so in an acceptable craftsmanship manner. All wall mounted equipment shall present a neat symmetrical appearance and be installed in a highly stable and rigid manner.

10.5.21 All equipment to be installed in the building shall be of high quality design and recommended or approved for commercial application.

10.5.22 Building and accessories when finished shall be complete in every respect and ready for use intended. Preliminary drawings shall be submitted for approval.

10.5.23 The Contractor shall furnish two sets of manuals covering all electrical equipment supplied with the building. These manuals will contain schematic diagrams, maintenance instructions and parts list as required.

10.5.24 The communication equipment building shall be positioned so that the side of the building adjacent to the tower, shall not be located at a point within _____ meter of the base of the tower. This to preclude damage to the building from ice, or other debris, falling from the tower surfaces.

11.0 STATION BATTERY SYSTEM

11.1 General

The dc power shall be furnished and installed as indicated in this specification.

All electronic equipment shall operate directly from a dc power supply consisting of a float-charged battery and battery charger operated from the station's power source.

11.2 Battery

_____ storage batteries shall be provided, designed for communications use.

11.2.1 Ampere-Hour Capacity: The ampere-hour capacity of the battery at each station shall be sufficient to carry the load of that station, as determined on "Battery and Charger Calculation Work Sheets" to be furnished by the Offeror. The battery shall be capable of supplying the station load continuously for a period of __ hours with electrolyte temperature of ____°C.

11.2.2 Number of Cells: Twelve cells for 24 volt and twenty four cells for 48 volt operation of the proposed equipment.

11.2.3 Grids: Offeror shall specify the percentage of calcium content.

11.2.4 Specific Gravity: The specific gravity of each cell shall be 1.210 ± 1.115 at ___°C after full charge. The cell voltage shall be between 2.20 and 2.30 volts when battery is floated at 2.25 volt per cell average.

11.2.5 Operation: All batteries furnished will be operating at a float voltage 2.25 volt per cell. No periodic equalization shall be required. The charger shall regulate the voltage to the battery terminals within ± 0.5 percent. The Offeror shall state the recommended maintenance for the batteries proposed.

11.3 Battery Rack

Battery racks shall be of the two-tier type. Frames, rails, and braces shall be made of steel. The final finish shall be an acid-resistant enamel.

11.4 Battery Records

The Offeror shall record the initial readings for the bus and each cell in accordance with the battery manufacturer's recommended procedures. The readings shall be witnessed by the duly authorized Purchaser's representative.

11.5 Cell Numerals

Plastic cell numerals shall be fixed to each cell starting with the numeral "1" at the positive terminal. The succeeding numbers shall then follow the electric circuit, ending with the numeral "12" or "24" on the cell at the negative terminal. The size of the plastic numeral shall be at least ____ cm and no greater than ____ cm. Each battery shall be assigned a serial number, which shall be fixed to each cell along with cell number at the factory.

11.6 Float Voltage

Batteries shall be suitable for float charge at 2.25 volt per cell.

11.7 Battery Connections

Electrical connections to the cell terminals shall use lead-plated copper lugs or straps to eliminate corrosion.

Intercell cell connectors and cables connecting the battery to the battery charger and the battery to the dc distribution cabinet shall be sized to coordinate with the battery charger dc output fuse.

11.8 Battery Accessories

Each site battery system shall be equipped with the following accessories:

- Hydrometer with markings every 10 points
- Thermometer, Battery
- Connector bolt wrench
- One acid-resistant container for storing the hydrometer
- Lifting sling and spreader block
- OSHA approved emergency eyewash kit

11.9 Discharge Curves

The Offeror shall provide copies of the battery manufacturer's discharge curves for each type of cell proposed. These curves shall be included in the Offeror's technical proposal, with calculations used to determine the capacity of the proposed batteries.

11.10 Battery Chargers

The battery chargers supplied under this specification shall provide full-wave rectification by means of silicon controlled rectifiers. These chargers will be used for float charging lead-calcium storage batteries. They shall operate from a 240 volt, single phase, 60 Hz source.

11.11 Standards

The following standards and specifications form a part of these specifications and, unless otherwise specified, all chargers shall be manufactured and tested in accordance with the applicable requirements of the following standards (latest versions thereof):

- National Electrical Manufacturer's Association (NEMA), Standard for Semiconductor Rectifiers Safety Code, Publication No. MR 1-1958

- EIA Standard No RS-262, Semiconductor Rectifiers Diodes, Class of Service Environmental and Test Requirements (NEMA Publication No. UD-49-1962)

11.12 Temperature Rise

Under continuous conditions and at maximum rated output with an ambient temperature of 40°C, the temperature rise of any charger component, shall not exceed the maximum continuous operating thermal limit specified in the individual standards of IEEE, NEMA and the National Electrical Code.

11.13 Operation

Chargers shall be supplied with control equipment to make them completely automatic as to output current and self-regulating as to output voltage. The output voltage shall be continuously adjustable over the range of 23 to 28 volts for the 24 volt batteries and 46 to 58 volts for the 48 volt battery. Controls that have erratic response will not be acceptable.

11.14 Regulation

The output voltage shall be constant ± one-half percent under the following conditions:

- Load: For any load from no-load to full-load
- AC Input Voltage: The ac input voltage variation of ± 10 percent
- Frequency: A frequency variation of ± ___ percent
- Completely independent of the battery

11.15 Current Limiting

The Chargers shall be self-limiting as to load current. The charger circuitry shall be such that the charger does not rely on the blowing of fuses or breakers to limit the current except under the short-circuit conditions. Limiting shall occur at 115 percent of maximum rated output.

11.16 Protection

The Chargers shall be equipped with fuses or protective devices to protect the charger components during fault conditions on the dc side of the charger, as well as during internal faults. Such protective devices shall provide fault protection on both the ac input and the dc output of the charger. The ac protection shall be properly coordinated with the dc protection for faults on the dc bus.

11.17 High Voltage

A high voltage sensing circuit shall be provided which will deenergize the charger output whenever the output voltage exceeds a preset voltage. This voltage shall be adjustable over the range of at least 26 to 29 volts for 24 volt batteries and 52 to 58 volts for a 48 volt battery in increments of 0.2 volt or less.

11.18 Discharge

Battery chargers shall be so constructed that the battery will not be discharged through the charger components during an ac supply outage. The current through the voltmeter or pilot light will not be considered as being sufficient to discharge the battery.

11.19 Capacity

Each battery charger shall have sufficient capacity to carry the full station load plus additional capacity sufficient to recharge a fully discharged battery within 24 hours after restoration of commercial power. The Offeror shall demonstrate the ability to meet this requirement by means of voltage and current measurement tests to the Purchaser's duly authorized representative at the time of acceptance. The full load capacity of the charger shall be specified by the Offeror in his proposal.

11.20 Control

The following control and instruments shall be provided on each battery charger panel:

- AC supply ON-OFF switch or circuit breaker
- Output voltage selector switches, adjustable knobs, for the adjustment of float charge voltage

11.21 Instruments

A dc voltmeter with a scale length of not less than _____ cm, with an accuracy of 2 percent, shall be provided on each charger.

A dc moving coil ammeter with an accuracy to within 2 percent of full scale shall be provided on each charger.

11.22 Alarms

The following alarms shall be provided with each battery charger:

- DC High Voltage alarm, adjustable from 26 to 29 volts for 24 volt chargers and 52 to 58 volts for 48 volt chargers
- DC Low Voltage alarm, adjustable from 21 to 26 volts for 24 volt chargers and 42 to 52 volts for 48 volt chargers
- Charge failure alarm relay

11.23 Enclosure

The Chargers shall be housed in metal enclosures designed to allow ready access for maintenance. The enclosures shall have sufficient louvers for adequate ventilation. Knockouts shall be provided convenient for the supply and load circuits. Terminals shall not be exposed when all covers are in place.

11.24 Terminals

All terminal blocks shall have their terminals marked to facilitate the identification of the particular terminal on the wiring or schematic diagram.

11.25 Filter

The output ripple voltage of the charger connected to the battery only, shall not exceed 30 MV rms.

11.26 Transformer

The battery charger shall have an isolating transformer with a dual primary winding.

11.27 Efficiency

The efficiency of the battery charger, at its rated full load with the nominal input voltage, shall be ___ percent, or greater.

11.28 Automatic Load Disconnect

The charger system shall be equipped with a load disconnect that automatically disconnects the load when the battery voltage goes below 21 volts on the 24 volt systems and 42 volts on the 48 volt systems.

11.29 Equalizing

The charger system shall be equipped with a timer assembly to permit equalizing of the battery bank. Equalizing system shall be defined.

11.30 Mounting

The charger system shall be of the rack mounting type for a standard EIA, 19 inch rack. This rack shall be floor mounted with the top of the charger at least ___ meters above the floor.

11.31 DC Power Boards

The dc power panel shall be provided for the distribution of dc power. The panel shall be equipped with indicator type fuses, as required by the station load. Redundant or standby equipment, if any, shall be powered from separate fuses. The panel shall be rack-mounted.

11.32 Ground Bus

The power board shall be equipped with a ground bus. The bus shall be drilled and tapped to accept solderless connectors. The ground bus shall also be rack-mounted and grounded to the relay rack.

11.33 Battery and Charger Servicing

Facilities shall be provided to enable the batteries and chargers to be maintained without interruption of service.

One set of Operation and Maintenance manuals shall be provided for each site, with two sets provided for office files.

12.0 TOWERS

12.1 General

This specification covers the requirements for the supply, delivery, and installation for ___ microwave towers, complete with tower lighting, footings, lightning protection and painting.

The towers to be furnished may be either Self Supporting, Multiple Leg Towers, or Single Pedestal, Guyed Towers. The single factor for selection, for all towers meeting or exceeding the requirements of this specification, shall be the overall, "In Place" cost of the tower, with the option for selection resting entirely with the Purchaser.

The towers furnished under this specification are to be delivered and installed at the sites indicated and pricing associated with these towers will be accomplished on this basis.

Buildings to house the communications equipment at each of the sites are hereinafter specified under Section _____ Paragraph _____ of these specifications, but the Purchaser reserves the option to either purchase these buildings together with the towers furnished, or to purchase the buildings from another source. Bids for all buildings should be priced separately from the towers, so that the Purchaser may evaluate the costs associated with the buildings, and exercise his option for purchase of the buildings, if he so desires. The pricing for the buildings should include all costs associated with the supply, and erection of the buildings.

To assure compatibility and compliance with not only National Codes and Standards, but Local Codes and requirements as well, it shall be the responsibility of each Offeror to insure that emplacement and erection of all towers, is in compliance with Local Codes, where applicable.

12.2 Specifications and Standards

The following specifications and standards (latest revision) shall be considered to be part of this specification. In the event of conflict between the requirements of this specification and the requirements of the referenced documents, the requirements of this specification shall govern.

EIA Standard RS-222C: Structural standards for steel antenna towers and other supporting structures

AISC Manual of the American Institute of Steel Construction

Department of Transportation - Federal Aviation Administration Advisory Circular AC 70/7460-IC: Obstruction Marking and Lighting

Federal Communications Commission - Rules and Regulations Part 17: Construction, Marking, and Lighting of Antenna Structures

American Welding Society (AWS) - Structural Welding Code AWS D1.1-Rev. 77

American Iron and Steel Institute (AISI) - Specification for the design of cold-formed steel structural members

National Fire Protection Association (NFPA) - NEPA-70 National Electric Code (NEC)

Federal Regulation Guide (FRG) - Title 47 - Telecommunications
Chapter 1 - Federal Communications Commission

Rural Electrification Administration (REA) - REA Bulletin 66-6
Power Systems Communication: Microwave Line of Sight (LOS) Systems

Federal Aviation Agency (FAA) - Part 77 - Objects Affecting Navigable Airspace (14 CIR 77)

ASTM A-36: Specification for structural steel.

ASTM A-53: Welded and seamless steel pipe.

ASTM A123 Standard specification for zinc (hot galvanized) coatings on products fabricated from rolled, pressed and forged steel shapes, plates, bars, and strip.

ASTM A143 Recommended practice for safeguarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement.

ASTM A153 Standard specification for zinc coating (hot dip) on iron and steel hardware.

ASTM A325	Standard specification for high-strength bolts for structural steel joints, including suitable nuts and plain hardened steel washers.
ASTM A375	Carbon steel plates, shapes and bars of structural quality not over 4 inches in thickness for use in construction of welded structures.
ASTM A384	Safeguarding against warpage and distortion during hot dip galvanizing of steel assemblies.
ASTM A385	Recommended practice for providing high quality coatings (hot dip) on assembled products.
ASTM A386	Standard specification for zinc coating (hot dip) on assembled steel products.
ASTM A446	Standard specification for steel sheet zinc coated (galvanized) by the hot-dip physical (structural) quality.
ASTM A475-A476	Standard specification for zinc-coated steel wire strand.
ASTM A440	High strength steel shapes, plates, and bars of structural quality intended for use in the construction of riveted or bolted structures (up to 4 inches thickness).
ASTM A441	High strength, low alloy structural steel shapes, plates, and bars for welded, riveted or bolted construction (up to 8 inches thick).
ASTM A242	High strength, low alloy structural steel shapes, plates, and bars for welded, riveted or bolted construction.
ASTM A307	Low carbon, steel externally and internally threaded standard fasteners.

ASTM A475 Specification for steel wire strand (galvanized).

ASTM A572 High Strength, low alloy Columbium-Van Adium steel of structural quality.

12.3 Tower Sites

The geographical locations, site elevations, above mean sea level (AMSL), and estimated tower heights for the towers to be furnished under this specification are as follows:

Site Name
Longitude
Latitude
Site Elevation _____ meters AMSL
Tower Height

Site Name
Longitude
Latitude
Site Elevation _____ meters AMSL
Tower Height

Site Name
Longitude
Latitude
Site Elevation _____ meters AMSL
Tower Height

Etc.

12.4 Contractor's Responsibilities

The Contractor shall:

12.4.1 Accomplish all required concrete work for the tower footings and building foundations, where buildings are included in his offer, including the preparation of sites. No site grading or leveling will be done by the Contractor. Any site clearing required will be accomplished by the Purchaser.

12.4.2 Provide the Purchaser with proper technical data necessary for state and local building permits.

12.4.3 Provide the Purchaser with a project work schedule within thirty (30) days prior to start of construction. This will include all sites listed in Section 12.3.

12.4.4 Be responsible for any loss or damage to crops, or property outside the assigned tower areas caused by his operations or personnel. Damages will be settled with the owner of the

property by the Contractor in the company of an agent of the Purchaser. Any damages or losses of livestock shall be the Contractor's liability. The Contractor shall submit the signed damage releases for any tower site concerned before final payment is made.

12.4.5 Remove all excess construction material such as crafting, packaging, forms, empty paint cans, or other rubbish from all sites on completion of construction. All sites shall be neat and free of debris prior to final payment.

12.4.6 Provide F.C.C. and F.A.A. permits and licenses.

12.4.7 Provide all modifications needed in existing building.

12.4.8 Provide connections to or from Purchaser's alarm reporting system.

12.4.9 Provide all fences which Purchaser may deem necessary.

12.4.10 Provide a site plot plan showing location of buildings towers and orientation of the towers prior to the start of construction.

12.5 Purchaser's Responsibilities
Purchaser Will:

12.5.1 Obtain all right-of-way, easements and property for location of buildings, towers, access roads and driveways.

12.5.2 Provide commercial power, 120/240 volt, 60 Hz, single phase, 3 wire, ____ ampere, to all sites including existing sites.

12.5.3 Coordinate access for Contractor's personnel at all site locations.

12.5.4 Provide building permits.

12.5.5 Obtain all required, Federal, local and state permits, including zoning permits.

12.6 Design

12.6.1 Towers shall be designed and erected for a design wind load of ____ kilograms per square meter and _____ cm, solid, radial, rime ice, on the tower, antennas, guys and all appurtenances simultaneously. The horizontal wind pressure shall be as given in EIA RS-222C (Section 2.2).

12.6.2 Tower shall be designed, fabricated and erected according to the latest EIA RS-222C specification. Where there is a conflict in specifications, the most stringent shall apply.

12.6.3 The shaft of guyed towers shall be supported on a pivot mount at the center of the foundation in a manner to prevent transmission of bending forces between the tower and the concrete base.

12.6.4 The towers shall be designed to minimize additional stresses from eccentric connections. Stresses resulting from eccentricity shall be included in the design analysis.

12.6.5 A complete detailed structural analysis of each tower shall be submitted _____ days after award of Contract to enable the Purchaser to check compliance with these specifications. All tower designs including a detailed structural analysis must be approved and certified by a Registered, Professional Engineer licensed in the State of _____.

12.6.6 Tower twist and sway limits and antenna beam movements with respect to the tower for specified half power beam widths shall be held within limits of EIA Standard RS-222C. All antennas shall be laterally braced as recommended by the manufacturer and torsion stabilizers shall be provided for guyed towers as necessary to comply with this specification. No towers shall have a face width less than _____ meters.

12.6.7 Designs shall consider bolted angular and tubular construction for the guyed or self-supporting type towers proposed.

12.6.8 The guy anchor shaft design shall permit the shaft to assume a direction in line with the resultant forces of the guys at any loading condition within the limits of this specification.

12.6.9 All towers shall conform to the minimum standards and requirements as outlined in EIA Standard RS-222C unless otherwise provided in these specifications.

12.6.10 Unit stresses shall be those referenced in EIA Standard RS-222C paragraph 3.

12.6.11 Guys shall have a factor of safety as determined and limited in EIA Standard RS-222C paragraph 8.

12.6.12 All components of towers and supporting elements shall be proportioned so that the unit stresses resulting from specified loads shall not exceed the allowable unit stresses of the "Specification for the Design, Fabrication, and Erection of Structural Steel for Buildings" issued by the American Institute of Steel Construction.

12.6.13 All parts of the tower, except stainless steel, including the anchor rods with guy attachment plates, but not including the guys, shall be hot-dipped galvanized as specified under ASTM Designation A-123.

12.6.14 All tower hardware such as bolts, nuts, turnbuckles, guy clips, etc., shall be coated as specified in ASTM Designation A-153.

12.6.15 Anco lock nuts shall be used to secure all bolted connections and shall conform to EIA RS-222C (paragraph 1.1.5.2).

12.6.16 Structural steel shall be in accordance with current ASTM specifications for structural steel for bridges and buildings, designation: A36, A441, A440, A573, or A242, latest revision.

12.6.17 If welding is employed in fabrication at factory, it shall be x-ray quality and must conform to AISC and AWS standards.

12.6.18 Any members that are buckled or bent must be replaced. All base shoes must be level and grouted. All bolts must be drawn up tightly against the member, and the bolt will have a minimum of two threads protruding beyond the nut.

12.6.19 All guy strands shall conform to ASTM A475, with Class A zinc coating.

12.6.20 The factor of safety of guys and their connections shall not be less than 2.5 as defined by EIA RS-222C (Section 8.1).

12.6.21 Guy hardware shall be capable of developing full breaking strength of the guy strand. Crosby clips shall be used to terminate the guy cable.

12.6.22 Tower guys shall be one continuous piece of strand from the guy anchor points to the tower. Splicing of guy strand is not acceptable. All guy tensions shall be adjustable to recommended values, using a properly calibrated strand dynamometer, to within _____ percent of calculated design values under normal wind conditions.

12.6.23 Each guy shall be attached to the guy anchor plate by a separate fixture. One bolt or fixture shall not be used at the guy anchor plate to terminate two guy lines.

12.6.24 To provide maximum use of turnbuckles, they shall be fully extended when initially installed, except that one complete thread shall remain exposed inside buckle body. After guy tensioning has been completed, all turnbuckles shall be secured with a piece of guy wire through the turnbuckle body and eyebolt, with the ends secured together with crosby clip.

12.6.25 In pulling guy strand, the "Chicago" type grip is recommended. The jaw of the grip shall be of sufficient length to take full lay of the strand, and the inside jaw contour shall be designed to avoid strand damage. "Haven" type grips with serrated jaw will damage strand and shall not be used.

12.6.26 Guy anchor heads shall be a minimum of _____ cm above ground level. Splicing of anchor rods is not acceptable.

12.6.27 Guy crossing of roadways or railroad tracks shall be arranged to have a minimum overhead clearance as follows:

- Roadway, _____ meters
- Railroad tracks, _____ meters

12.6.28 Templates shall be used to install anchor bolts in the concrete, and care shall be exercised to keep such inserts in position until concrete has set. The exposed threads of all concrete bolts shall be left clear of concrete.

12.6.29 Contractor shall protect all existing buildings, structures and equipment during the fabrication and erection of the tower from falling objects, including paint. Contractor shall be liable for any damage caused to such buildings and equipment.

12.6.30 For design purposes, all towers shall be designed to mount ____ each, ____ meters diameter, standard performance, parabolic antennas (_____-East-West).

12.7 Footings and Foundations

12.7.1 Foundations and guy anchors shall be designed in accordance with EIA Standard RS-222C, Section 7 or latest revision thereof.

12.7.2 Soil testing, if required, will be performed by the Purchaser. The results of these tests will be forwarded to the Contractor and shall form the basis of his tower and foundation design. Assume _____ psf normal soil.

12.7.3 With the structure and antennas subjected to the design wind loading, the specified allowable soil bearing pressures and uplift resistance shown in EIA RS-222C, Section 7 shall not be exceeded.

12.7.4 The Contractor will furnish all necessary personnel, supervision, tools, equipment, materials and transportation required to complete the installation and erection of all items specified herein for purchase.

13.7.5 The Contractor shall provide all necessary services to haul, handle and unload the materials he is to furnish and install.

12.7.6 The Contractor shall furnish all necessary labor and equipment to locate the tower vertical center point, guy anchor, footing, and foundation positions.

12.7.7 Prior to start of construction, Purchaser shall review staking at the site. No work shall be done without Purchaser's approval. All submittal data must receive full approval of Purchaser before commencing tower erection.

12.8 Excavations

12.8.1 The natural earth at each site shall be disturbed as little as possible during construction. In all cases, the ground surface at each site shall be restored to the original grade level and completed reasonably smooth and compact.

12.8.2 Suitable excavated material shall be placed in back-fill or in graded embankment by the Contractor in the immediate vicinity of the towers, as directed by the Purchaser.

12.8.3 Foundations in earth shall be excavated to clean level surfaces of undisturbed material of adequate bearing value. Over excavation shall be backfilled with a stone or gravel base material in ____ cm layers well compacted or shall be filled with concrete. In either case, the cost of the backfill or additional concrete used in the foundation shall be borne by the Contractor. Where water is encountered, the hole shall be kept dry by pumping during the installation of the foundation and during the backfilling process.

12.8.4 Where loose rock or boulders are encountered extending above the proper elevation of the concrete slab footings base, they shall be removed to a depth approximately ___ cm below the footing base. The resulting depression shall be backfilled with selected borrow well compacted to assure an even bed for bearing. The additional excavation and backfill so required shall be considered work incidental to the installation of the footing.

12.8.5 The stone or gravel base cited above shall consist of a mixture of graded aggregate, coarse and fine, together with soil binder.

12.8.6 Foundation excavations shall be maintained in a safe, clean and sound condition up to the time of placement of footings. All holes shall be protected when not attended. Whenever necessary, the Contractor shall re-excavate materials which have accumulated in previously prepared holes. Any unsatisfactory bearing material resulting from frost action or entrance of water into excavations shall be removed and replaced with well compacted stone or gravel backfill at the Contractor's expense.

12.8.7 The Contractor shall do all bracing, sheeting and shoring necessary to perform and protect all excavations as required for safety and to conform to laws and regulations of government bodies having jurisdiction. When sheeting is used, it shall be removed during or upon completion of backfilling.

12.8.8 Selected earth borrow shall be used as backfill material when the excavated material has been deemed unsuitable.

12.9 Concrete

12.9.1 All concrete for the work shall conform to the requirements of the latest edition of the "Building Code Requirements for Reinforced Concrete" of the American Concrete Institute, Designation ACI-318, except as modified herein, and to the latest revision of the following:

12.9.2 Standard Specification for Concrete Aggregate, ASTM Designation C33.

12.9.3 Standard Specification for Ready-Mixed Concrete, ASTM Designation C94.

12.9.4 Standard Specification for Air-Entrained Portland Cement, ASTM Designation C175.

12.9.5 Air-Entraining Portland Cement or approved equal shall be used.

12.9.6 Ready-Mixed Concrete shall be used for all work.

12.9.7 The concrete for tower foundations shall have a minimum compressive strength of _____ psi at ___ days and a minimum cement content of ____ bags per cubic yard of concrete. Slump for all concrete shall not exceed ___ cm and air entrainment shall be between __ and __ percent of the volume of concrete. The strength at ____ days shall be at least ___ percent of that specified for ____ days.

12.9.8 No concrete shall be placed until all form work, installation of parts to be embedded, and preparation of surfaces involved in the placing have been approved. No concrete shall be placed in water, except with permission of Purchaser and the method of depositing the concrete shall be prescribed by the Purchaser. Concrete shall not be placed in running water and shall not be subjected to the action of running water until the concrete has hardened.

12.9.9 All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, or with ice, mud or other foreign material shall be cleaned of all such refuse before the surrounding or adjacent concrete is placed.

12.9.10 Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud and other foreign material.

12.9.11 The surfaces of concrete which have set, and against which new concrete is to be poured, shall be thoroughly cleaned to remove all foreign material and be saturated with water immediately before placing concrete. Concrete shall be deposited continuously and as rapidly as possible until the unit being poured is completed.

12.9.12 The temperature of concrete when being placed shall be:

- Not less than ___°C in moderate weather
- Not less than ___°C in weather during which the daily temperature drops below ____°C
- No greater than ____°C during hot weather

12.9.13 The Contractor shall protect all concrete against injury. Temperature shall be controlled by controlling the temperature of aggregate and mixing water. Mixing time should be kept at a minimum and elapsed time between mixing and placing should be minimized. The interior surfaces of forms and the ground upon which concrete is to be poured should be thoroughly wetted before the concrete is poured.

12.9.14 After the first frost, and until the mean daily temperature in the vicinity of the work falls below ___°C for more than one day, the concrete shall be protected against freezing for not less than ___ hours after it is placed. Whenever the mean daily temperature in the vicinity of the work falls below ___°C for more than one day, the concrete shall be maintained at a temperature not lower than ___°C for at least ___ hours after it is placed and shall be protected against freezing for _____ days immedimately following the ___ hours of protection at ___°C. Discontinuance of protection against freezing shall be such that the drop in temperature of any portion of the concrete shall be gradual and will not exceed ___°C in ___ hours.

When the mean temperature rises above ___°C for more than _____ successive days, the specified ___ hour protection at a temperature not lower than ___°C may be discontinued, but the concrete shall be protected against freezing for not less than ___ hours after placing. When artificial heat is employed, special care shall be taken to prevent the concrete from drying.

12.9.15 Forms shall conform to the shape, lines and dimensions of the concrete as proposed and shall be sufficiently strong to carry the dead weight of the concrete without undue deflection or bulging, and sufficiently tight to prevent leakage of mortar. They shall be properly braced and tied together so as to maintain position and shape.

12.9.16 Reinforcing bars shall be made from intermediate grade, billet steel in accordance with the latest requirements of ASTM Designation A15. Deformations on reinforcing bars shall conform to the latest requirements of ASTM Designation A-305.

Reinforcing bars shall be accurately placed and secured in position so that they will not be displaced during the placing of the concrete, and special care shall be exercised to prevent any disturbance of the reinforcing bars in concrete that already have been placed. Rust-proof metal chairs, metal hangers, metal spacers, or other satisfactory metal supports may be used for supporting reinforcing bars. Precast concrete blocks may be used for supporting reinforcing bars.

12.9.17 The building footings shall be steel reinforced concrete having a minimum yield strength of ___ psi. A sufficient cap with anchor fittings shall be poured on the footing at the same time the footing is poured. If drilled foundations are used, the bottoms shall be belled out to a diameter of at least one foot greater than the diameter of the hole. In suitable solid rock, rock anchors set in grout in drilled holes may be used.

12.10 Structure Erection

12.10.1 Tower erection shall be in accordance with instructions issued with the design data.

12.10.2 Initial guy tension shall be achieved in accordance with instructions issued with the tower drawings.

12.10.3 All tower sections assembled on the ground shall be blocked off the ground using wood blocking so as to be free of dirt, mud and other foreign materials that tend to adhere to the structure. If erected by assembling in sections, initial bolting shall be adequate for dead load, live load and erection stresses, but shall not be so tight as to prevent aligning and fitting adjacent sections or members.

12.10.4 No work shall begin on the tower foundation until FCC-FAA construction permits have been obtained by the Purchaser. It is the responsibility of the tower contractor to obtain all local construction permits.

12.10.5 Tower foundations shall be allowed to cure for at least _____ days before placing or erecting the tower. No differential settling will be allowed in tower footings.

12.10.6 Correct length of bolts shall be used for all connections in accordance with the bolt assembly lists furnished by the tower manufacturer. Bolts shall be installed so that the nuts are on the outside or on top of the tower members. Bolts should be of such lengths as to protrude beyond the nuts a minimum of _____ cm and a maximum of _____ cm. All bolts shall be equipped with lock-nuts, lock washers, pal-nuts, or self-locking nuts. Misaligned holes requiring reaming must be completely filled by the use of a larger diameter bolt.

12.10.7 Mud, dirt, and other foreign matter shall be removed from the members before erection, with special attention given to cleaning the contact surfaces at joints before they are bolted together.

12.10.8 When portions of the tower are ground assembled, such assembly shall be on surfaces or blocking which will provide support to prevent distortion of tower steel and damage to surface finish. All bolts shall be installed in all connections of ground assembled portions of the tower. Temporary bracing of tower members shall be used to avoid overstressing or distortion.

12.10.9 The tower shall be erected plumb. The method of assembling and erecting shall be such that no member will be subjected during erecting to a load in excess of that for which it was designed. Extreme care shall be taken to establish and maintain the true geometric shape of the portion of the tower assembled. All connections must lay flat where they bolt together. No gaps between butt flanges or connections are acceptable after the bolts are tensioned.

12.10.10 Slings or other equipment used for picking up members or portions of towers shall be of such material or protected in such a way as to not cut into corners of the members, damage the finish, or distort or overstress members when heavy lifts are made. Members or portions of towers shall be raised in such a manner that no dragging on the ground or against portions of towers already erected will occur.

12.10.11 Members bent or distorted in handling may be used if they can be straightened without structurally damaging the metal. If bent members cannot be repaired to the satisfaction of the Purchaser, they shall be replaced. Any galvanized surfaces which are damaged for any reason shall be touched up with one coat of galvanized paint.

12.11 Painting

12.11.1 Microwave towers shall be painted for aerial visibility marking in accordance with the Federal Aviation Administration's applicable regulations. The surface of all tower members shall have alternate bands of Aviation Orange and White paint furnished and painted before tower erection by the Contractor. After erection, all painted or galvanized surfaces marred during erection shall be repaired with paint or galvanize.

12.11.2 The Contractor shall prepare the surface to be painted so that it is clean and free of all dust, dirt, oil, grease, earth, moisture, loose rust, and loose scale and other undesirable residue immediately before the application of paint. Mechanical cleaning shall be used to remove solid residue such as rust and earth by scraping, wire brushing, or sanding until a sound metal or painted-surface remains. All paint shall be thoroughly mixed immediately prior to and during application. Paint shall not be applied to surfaces which are more than ____°C below air temperature. Paint shall not be applied in rain, fog, mist, snow, or when relative humidity exceeds _____ percent.

12.12 Lighting

12.12.1 Obstruction lighting shall be furnished and installed on new towers at elevations in accordance with the Federal Aviation Administration's applicable regulations.

12.12.2 The Contractor shall furnish, install, wire and connect on the tower all necessary conduit, junction boxes, obstruction lighting, fixtures, automatic controls, flasher and alarm relays with weatherproof enclosures. The Contractor shall bring all wires and make all necessary connections to the building distribution panel for all tower and building equipment. The 120/240 volt, single phase, 3 wire power supply to the building distribution panel will be supplied and connected by the Purchaser.

12.12.3 The obstruction lighting system shall consist of the following items supplied at each tower.

- A photoelectric device to turn tower lights on and off in accordance with FAA regulations
- A flashing device for turning code beacons on and off in accordance with FAA regulations. Failure of the flasher shall cause the code beacons to burn continuously
- Normally closed alarm contacts supervised by the photoelectric device shall be provided to indicate by their opening that one or more of either the code beacons, beacon flasher or side lights have failed. Sidelights and code beacon with flasher shall have separate alarm contacts. The photoelectric device supervision is to be provided for the exclusion of daylight alarming.
- Obstruction beam lighting fixture, 300 mm, red hazard Fresnel lens, two 620 watt lamps wired in parallel mounted to provide 260 degree horizontal visibility
- Two continuously burning sidelights at each elevation required by the FAA for each tower
- All bulbs shall be the long life (3000 hour) type or better
- A lightning arrestor protector shall be provided for the sidelight circuit and the obstruction beacon circuit

12.12.4 The Contractor shall provide temporary obstruction lighting during tower erection as required by the FAA construction permit. Source of temporary electric power for this purpose shall be taken from 120/240 volt service provided by Purchaser.

12.13 Grounding

12.13.1 All ground rods and ground wires shall be in accordance with EIA RS-222C. The top of ground rods shall be no more than _____ cm below grade.

12.13.2 A heavy-duty lightning rod shall be securely attached to the top of each tower.

12.13.3 Where microwave towers and equipment are next to a high voltage substation, all inputs and outputs must meet the requirements of the IEEE surge wave test. Tower and building grounding must be designed to protect against ground potential rise between the substation and microwave installation.

12.14 Waveguide Bridges

Waveguide bridges and ice guards shall be furnished over all horizontal waveguide runs. All material used shall be galvanized or rustproof and shall be painted.

12.15 Ladders

All towers shall be equipped with climbing ladders inside the tower with a minimum _____ cm step length and a maximum step separation of _____ cm. A climbing safety device shall be included with the ladder and shall meet the design requirements of the American National Standards Institute (ANSI) A14-3, "Safety Code for Fixed Ladders."

12.16 Tower Drawings, Design Analysis & Instructions

12.16.1 Preliminary Drawings: The Contractor shall furnish two copies of the following drawings and instructions:

- Preliminary design drawings for all towers, showing location of attachments, supports, and base plates
- Preliminary design drawings of antenna support members
- Preliminary design drawings of guy anchors, foundations, reinforcing steel, etc.

12.16.2 Approval Drawings: The Contractor shall furnish two copies of all drawings to purchaser for approval before placing the work in the shop. Such drawings shall be submitted as soon as possible after the issuance of the

"Preliminary" drawings mentioned above and shall, if at all possible, be the same drawings.

The Contractor shall furnish three print copies of all assembly and adjustment instructions for towers, including proposed method of achieving initial tension in guys.

12.17 Material Certification

Contractor shall provide certified mill test reports, certified reports of test reports, certified reports of tests made by the fabricator or a testing laboratory or an affidavit stating that all material furnished meets the requirements of the applicable referenced specification.

12.18 Inspection

The Contractor shall carefully inspect the entire tower to be sure of full compliance with the specifications and to avoid returning to the site for corrections. Special emphasis shall be placed on locking devices, all nuts being perfectly tight, complete tower markings, guy properly tensioned and served, tower plumb, and tower twist. The tower site shall be cleared of all cans, guy wire ends, boxes, crates, rubbish and other surplus materials incident to the work.

13.0 INSTALLATION

13.1 General

The communications equipment, towers, buildings, and other materials shall be installed by the Contractor in a neat and professional manner, employing the highest standard of workmanship and in compliance with the National Electrical Code, Electronic Industry Association (EIA) standards, local building codes, applicable FCC of FAA standards and procedures, and standard construction procedures.

13.2 Specific

The Offeror shall furnish all equipment, materials, and services as required to provide a complete and functional system as described by these plans and specifications. Work at each site shall include, but not be limited to the following. All work shall be in compliance with the applicable drawings and/or specification requirements. In accomplishing installation, the Contractor shall:

- Extend temporary electrical service from fusible disconnect on power service pole. Pole and service riser shall be furnished by the Purchaser
- Stake tower base and guy anchor locations
- Install tower foundations and guy point anchors as required. Included shall be any fill or equipment required to gain access to the foundation locations
- Prepare grade for equipment building slab foundation and construct slab. Included shall be sleeves, conduit, etc., as required for power, grounding, and signal cable
- Erect tower and install tower lights
- Install station signal grounding system
- Erect communication equipment building
- Furnish and install waveguide bridge between equipment building and tower
- Furnish and install permanent electrical wire service, and cabling in building
- Complete final installation of tower lighting system. Connect tower lights to lighting control unit

- Bond building grounding system to station ground
- Install lightning protection equipment
- Install antenna systems
- Install communication equipment and all power and signal cables extending to adjacent racks in overhead mounted raceways or cable trays supported from the ceiling of the equipment building. Furnish and install raceways as required
- Support all RF transmission lines at points every three feet with cable hangers if not installed in raceways
- Install batteries, charger, and DC distribution panel. Panel to be furnished as part of communication equipment
- Install transmission line pressurization and dehydration system
- Install all interconnects between alarm contacts for building and communication equipment to alarm status panel
- Install ground bonds between communication equipment and station signal ground
- Install and connect the protective grounding system wire
- Install all inter-rack and communication equipment wiring
- Install such other facilities as required by these specifications

During the entire installation phases, it shall be the responsibility of the Contractor to coordinate all construction and installation activities with the Engineer to assure rapid and effective realization of the system to be furnished under these specifications.

14.0 TESTING

14.1 General

Buildings, towers, communication equipment plus other equipment and materials included in these specifications will be inspected and tested as appropriate by the Purchaser and the Engineer. The inspections and testing as specified herein will be conducted during the delivery and installation phases of the project, with final acceptance testing to be conducted at such time as the Contractor states that the system installation is complete, and ready for test.

The tests will be conducted to verify that all equipment called for by these specifications has been engineered, furnished and installed as specified, is functioning as called for, and that all work specified has been completed in accordance with the Purchaser's requirements.

14.2 Test Schedule

The Contractor shall provide the Purchaser with advance notification of tests to be conducted as follows:

- Factory Testing - ___ weeks
- Field Tests - ___ weeks

Field tests shall be conducted on subsystems by the Contractor on a basis to be specified by the Purchaser subsequent to contract award.

14.3 Test Procedures

Prior to initiating any tests, the Contractor shall develop a system test procedure and format for test documentation. It shall be the intent to allow the Contractor maximum flexibility in establishing test procedures in order to use procedures and practices familiar to the Contractor. If these procedures and practices are not acceptable to the Engineer, the procedures and practices established by the Engineer shall be used.

Prior to witnessing of field acceptance test by the Engineer, the Contractor shall conduct tests and record data for review and evaluation by the Engineer. The Contractor shall verify in writing that the system is ready for acceptance testing and that all facilities and systems are in compliance with the plans and specifications.

14.4 Retest Requirements

In the event that any facility is found to be deficient, or any communication test does not meet or satisfy the requirements of the specification for the test, action, as directed by the Purchaser's Engineer, shall be taken by the Contractor to correct the deficiencies noted, prior to

additional system testing. Tests shall be conducted, as required, until the deficiencies are corrected, and the system is operationally acceptable.

14.5 Test Equipment

It shall be the responsibility of the Contractor to furnish all equipment required to conduct system tests. All equipment shall be calibrated and calibration data made available to the Engineer upon request.

Prior to initiation of acceptance tests, the Contractor shall submit a list of test equipment (by types) to be used. Equipment shall be as referenced in the Test Procedures.

Types, model numbers and serial numbers of specific equipment used for system testing shall be included with each station test report.

14.6 Factory Testing

Factory tests shall be conducted by the Contractor and may be witnessed by the Engineer. It is desirable to conduct all tests consecutively for the entire system; however, subsystem tests will be acceptable if required to expedite completion of the project. Tests shall include all items as noted herein. Attenuation shall be inserted to simulate antenna system and free space net loss for each path.

Factory tests shall be conducted with levels and adjustments set for nominal conditions expected in the field.

Factory test data on multiplex channelization equipment, shall be submitted to the Engineer for review and record purposes. If requested, sample tests of multiplex and signaling equipments shall be witnessed by the Engineer at no additional cost to the Purchaser.

14.6.1 The microwave equipment shall be assembled at the Contractor's factory, where tests shall be performed both on the individual equipment basis, and on a link basis to prove compliance with the performance objectives.

14.6.2 Contractor shall notify Purchaser at least ____ days prior to final factory testing and shipment to allow engineer and/or his representative to witness final testing of the equipment to be supplied.

14.6.3 Data recorded during factory testing will be compared with data obtained during field testing.

Offerors are to describe, in detail, their standard factory testing procedures and practices for each type of electronic equipment offered.

14.6.4 Contractor shall submit the factory test plan within ___ days after contract award for review and approval.

14.7 Field Tests

During the checkout and field testing, the Purchaser shall assign personnel to participate with the Contractor in the checkout of the system. A notification of _____ working days shall be given to engineer to allow for possible assignment of Purchaser's personnel. Offerors are to explain, in detail, their standard field testing practices and procedures for all equipment offered. The Contractor shall submit within 60 days of contract award a field test plan for review and approval.

14.7.1 Documentation

Data obtained during the field testing shall be fully documented, with the original copies of the documentation furnished to the Purchaser. The documentation shall include as a minimum, the following information:

- Site Name
- Test equipment utilized
- Fade margins noted on a per hop basis
- Noise power ratio test data on a per hop basis
- Proper equipment levels in accordance with Contractor supplied block and level diagrams
- Proper and effective operation of representative multiplex circuits

Data recorded during these tests shall be checked against that obtained during factory tests.

14.8 Performance Tests

14.8.1 DC System Tests

The chargers and dc power boards shall be tested and adjusted to verify the following:

- Float voltage
- Charger operation
- Current limiting
- Meter accuracy
- Output ripple
- High-voltage trip and alarm
- Low-voltage switch operation
- Manual disconnect switch operation

The batteries shall be tested to verify the following:

- Cell voltage
- Cell specific gravity
- Battery bank voltage

The chargers shall be disabled for one hour and the above tests shall be performed again to check for defective cells in the battery bank.

14.8.2 Antenna Tests

All transmission lines shall have been tested by the antenna system manufacturer, for return loss (VSWR) utilizing a reflectometer technique. VSWR shall not exceed _____ for the complete antenna system.

Transmission line pressurization system shall have been tested by the antenna system manufacturer, isolating each individual transmission line run under a pressure of __ PSI for four hours. The loss in pressure is not to exceed ___ PSI in 4 hours.

Antenna gain tests shall be conducted to insure stated manufacturer's performance.

14.8.3 Microwave Radio System Tests

14.8.3.1 Net path loss measurements shall be performed at each site and the following information recorded:

- Transmitter output
- Receive carrier
- Net path loss

14.8.3.2 The measured path loss on any path shall not exceed the calculated value by more than ___ dB. Received carrier shall be measured during the substitution technique.

14.8.3.3 Intermodulation (NPR) tests shall be performed on a link and subsystem basis.

14.8.3.4 Frequency response tests shall be performed on a link and subsystem basis.

14.8.3.5 The AGC voltage vs receiver carrier shall be tested and recorded.

The receiver squelch shall be tested to assure squelch at level in specification.

14.8.4 Service Channel (OW)

14.8.4.1 The service channel shall be tested to assure proper operation with the following items tested and recorded: 14.8.4.2 - NOT USED

- Signaling operation
- Transmit level
- Receive level

14.8.5 Fault Alarms

14.8.5.1 The fault alarm system shall be tested at both the remote sites and master station. Alarms will be simulated by jumpering of the contacts or other similar method.

14.8.5.2 The site transmitters shall be tested for proper transmit levels, with each fault point tested by simulating a fault. A check shall be made to verify that the proper alarm indicator on the transmitter is activated and that the fault is reported properly at the master station.

14.8.5.3 The audible and visual alarms at the master receiver station shall be tested.

14.8.6 Multiplex Tests

14.8.6.1 The multiplex equipment shall be fully tested, with the tests performed in accordance with accepted procedures, and all data taken shall be recorded. The following tests shall be performed:

- Channel frequency response of each voice channel
- Channel crosstalk
- Harmonic distortion
- Hybrid balance
- Intermodulation products
- Signaling speed and sensitivity
- Sensing circuit operation
- Channel level stability
- Frequency generation accuracy
- Power supply voltage and ripple
- Proper operation of all alarms
- Operation of control and indicators
- Adjustment range of all variable devices
- Delay distortion
- Idle channel noise
- Carrier leak

All measurements shall be made after all levels have been properly adjusted.

14.8.6.2 Channel frequency response tests shall be made from mod-in to far end demod-out.

14.8.6.3 Crosstalk measurements shall be made on an individual channel basis for both near-end and far-end crosstalk.

14.8.6.4 The crosstalk performance shall be measured using a Western Electric 3A or 2B test set or equivalent.

14.8.6.5 Harmonic distortion tests shall be made using a 1 kHz test tone at 0 test tone level as a reference signal. A harmonic wave analyzer shall be used at the equipment receiving terminal to measure the level of the fundamental and harmonics of the applied signal.

14.8.6.6 Frequency generation shall be tested for proper output of all carrier and pilot levels. The master pilot oscillator frequency shall be tested by using an electronic counter.

14.8.6.7 The idle channel noise of each carrier drop, shall be measured using a Western Electric 3A or 2B noise measure test set or equivalent. This measurement shall be made over the microwave system under normal propagation.

14.8.6.8 Carrier leak shall be tested at channel and group points, and shall not exceed the Manufacturer's specifications.

14.8.6.9 All other multiplex tests specified shall be performed in an acceptable manner and data shall be recorded.

14.8.7 Sensing and Alarm Circuits (Radio and Multiplex)

14.8.7.1 All sensing circuits, in the radio and multiplex, shall be tested for proper operation. Range of all variable devices shall be tested to assure that reserve adjustment is available, if required. Equipment failure and fuse alarms shall be tested and checked to verify that the proper point on the fault alarm is activated and the required visual and/or audible alarms occur.

14.8.7.2 All meter indications shall be tested to assure proper function. Range of adjustments for meter indication shall be tested.

14.8.8 Alarm External to Microwave Equipment

14.8.8.1 The external alarms shall be tested to verify that the proper indications appear on the fault transmitter and that these alarms are received at the Headquarters control station.

14.8.8.2 All alarms shall be checked and tested for proper operation by actual failure, if feasible.

14.8.9 On Site Inspections and Tests

All facilities and communication equipment shall be inspected and tested to insure compliance with the plans and specifications. This shall include, but not be limited to the following:

- AC power systems
- DC power systems
- Emergency generator
- Building HVAC systems
- Alarm system
- Pressurization system
- Tower lights
- Tower
- Grounding system
- Cable terminations and protectors
- Station licenses
- Order wire
- Antenna system
- Antenna system VSWR
- v.f. channels

14.8.10 Link Tests

14.8.10.1 Each microwave link shall be tested to verify compliance with the plans and specifications. Tests shall include, but not be limited to the following:

- Transmitter frequency
- Transmitter power
- Nominal receive level
- IF output
- Noise measurements
- Fade margin
- Squelch level
- NPR
- Transmit pilot
- Receive pilot

14.8.10.2 Where applicable, results of tests shall equal or exceed specified, and Contractor supplied performance data. Link tests shall be witnessed by the Engineer.

14.9 System Acceptance

14.9.1 General

Acceptance of the Communications System shall be on a system basis. _____ days prior to completion of the system, the Contractor shall notify the Purchaser. This will allow a coordinated inspection, testing and acceptance schedule to be organized by the Contractor and the Purchaser.

14.9.2 Acceptance Criteria

Buildings, towers, and equipment will be accepted if by physical observation the facilities satisfy the intended requirements of the plans and specifications.

Communication equipment will be accepted if the physical equipment is furnished and installed in accordance with the specifications and the communication or electrical performance characteristics of these specifications are satisfied.

Upon compliance with plans and specifications, the entire system or subsystems will be accepted as complete as determined by the Purchaser and the Engineer.

14.9.3 Station and System Acceptance

Owner reserves the right to perform or have performed by the Contractor any testing to verify system specifications. Acceptance of part of any system will not obligate Purchaser to accept remaining parts of the system. Warranties shall not commence until final system acceptance.

The Purchaser will not make final payment to Contractor until the Purchaser's Engineer has certified that the communications system furnished and tested by the Contractor is operating in conformance with specifications and guarantees.

15.0 DOCUMENTATION

15.1 Within ____ days subsequent to date of contract award, the contractor shall furnish for Purchaser approval, a minimum of ___ sets of preliminary systems drawings and documentation consisting as a minimum of the following:

15.1.1 A key or index sheets listing in a numerical sequence all drawings and descriptive literature.

15.1.2 Rack elevations showing rack dimensions on all equipment units and their location on the racks.

15.1.3 _____ operational instruction books, including schematic diagrams for each different type of unit furnished shall be sent with the preliminary drawings to facilitate interpretation and approval of the drawings.

15.1.4 Operational block diagrams covering system function, alarm system and signal flow.

15.1.5 Manufacturer's assembly and installation drawings for antennas.

15.1.6 Communication equipment building physical layouts and structural drawings with dimensions. Included shall be drawings and descriptive data on all equipment included as part of the equipment building.

15.1.7 Drawings showing physical mounting details of all equipment and hardware furnished.

15.1.8 Details on station and equipment grounding.

15.1.9 Detailed building wiring drawings showing wire sizes and runs.

15.1.10 Wiring harness drawings and cable running lists for all racks, to include wiring of all plug-in shelf assemblies, showing wiring connections between units on a shelf and inter-rack wiring. Where vendor standard wiring assemblies are used, they shall be marked or otherwise cross-referenced to indicate applicable options and strappings. Units wired but not equipped shall be so indicated. External connections to all racks. All external connections, such as for power, alarm, audio, etc., shall be cross-referenced on the key or indexed sheets.

15.2 The Contractor shall furnish for approval, within ____ days after the contract award, his proposed system test procedures.

15.3 The Purchaser will, within ____ days after receipt of prints of drawings and design analysis for approval, forward one copy of each to the Contractor marked with one of the following:

15.3.1 Approved: Prints so marked will authorize the Contractor to proceed with the fabrication of the equipment.

15.3.2 Approved With Corrections: Prints so marked will authorize the Contractor to proceed with the fabrication of the equipment in accordance with indicated corrections. The Contractor shall make the necessary drawing revisions.

15.3.3 Returned for Correction: The Contractor shall make the necessary corrections and revisions on the drawings as indicated and shall resubmit prints for approval. Time required for such revision of drawings and resubmission of prints will not entitle the Contractor to any extension of time.

15.3.4 Work accomplished, or materials ordered, by the Contractor, prior to receipt of prints marked Approved or Approved With Corrections As Noted, shall be at the Contractor's risk. Approval by the Purchaser shall not relieve the Contractor of the responsibility for the correctness of the drawings furnished by the Contractor nor for their compliance with the specifications.

15.4 The Contractor shall furnish, within ___ days after system cutover the following documentation and manuals:

15.4.1 ____ sets of Instruction Manuals, covering the microwave equipment, incorporating, as a minimum the following information:

15.4.1.1 Complete system installation, operating, and line-up instructions.

15.4.1.2 Instructions for each different equipment unit furnished, including operating and maintenance instructions, parts lists, and schematic diagrams.

15.4.1.3 For units not manufactured by the radio equipment supplier, the manufacturer's name and his identifying part number shall also be furnished.

15.4.1.4 Operational block diagrams covering all system functions.

15.4.2 One set of Instruction Manuals per station covering the battery chargers, air conditioners if being furnished, and test instruments incorporating the following information:

15.4.2.1 Complete installation, operating, maintenance, and line-up instructions.

15.4.2.2 Complete schematic and wiring diagrams.

15.4.2.3 Complete parts lists.

15.5 The Contractor shall supply for each site, _____ copies of a certified factory test report. This test report shall contain data and meter readings taken during final factory alignment of equipment. No equipment will be acceptable which has a reading or readings not within the stipulated and agreeded upon tolerances listed in the instruction book. The test report shall contain overall system performance data to indicate compliance with all system tests. Three copies of system test reports containing the overall system performance data of the system field tests shall be furnished within ____ days after completion of tests.

15.6 The Contractor shall prepare a set of "as-built" drawings and submit these to the Purchaser's Engineer for final approval.

15.7 The successful Contractor shall be responsible for placing the Purchaser's name and address on the mailing lists of the manufacturers of all items furnished under these specifications, so that the Purchaser may receive all literature and data associated with any design modifications or alterations made by the manufacturers subsequent to the acceptance of the system by the Purchaser, and for a period of ____ years.

16.0 SPARE PARTS AND TEST EQUIPMENT

16.1 General

This section describes the requirements for spare parts and test equipment for the operation and maintenance of the system to be furnished. Parts, modules and test equipment to be recommended by the Offeror, but not manufactured by him, shall be indicated as such, and the manufacturer of the item stipulated. Common parts such as transistors, diodes, etc., that are available from more than one source shall be shown as such and the manufacturer's name will not be required.

The unit price of each item of Offeror manufactured test equipment shall be shown, indicating any discount advantage obtained by purchasing the test equipment from the Offeror at the time the system is ordered.

16.2 Spare Parts and Modules

A recommended spare parts list for the first year of operation on the system shall be provided. The spare parts list shall include prices of the individual modules, sub-assemblies, or spare parts as itemized and the total spare parts cost shall be given as required in this specification. Spare parts or sub-assemblies for the following shall be provided:

- Battery equipment
- Radio equipment, 2 GHz and VHF
- Multiplex and signaling equipment
- Order wire
- Antenna system
- Alarm system

Spares for the equipment shall be recommended at the module level of repair and maintenance. This shall include sub-assemblies, modules and plug-in units.

Facilities available for return of units, subsystem, sub-assemblies and modules to the manufacturer for repair shall be described by the Offeror. The turn around time, for shipping the unit in for repair, and return, shall be stated by the Contractor.

Spare parts and modules shall be available for _____ years after acceptance of the system by the Purchaser.

16.3 Test Equipment

A list of test equipment required for maintenance of the proposed system shall be provided. It shall indicate the suggested minimum amounts and types of equipment required for proper maintenance. In addition, test equipment should be recommended to perform complete equipment alignment, testing and repair. If test equipment is of other manufacture than by the Contractor, it shall be so indicated.

17.0 TRAINING

17.1 General

The Offeror shall conduct a complete maintenance and operation training program for up to _____ persons. This program shall consist of at least _____ hours of instruction, including the general theory of operation of the radio equipment, multiplex, and other associated equipment. Test procedures to be followed in keeping the equipment in operating condition, emergency procedures, and routine maintenance acts shall include actual adjusting and testing of equipment furnished to the Purchaser on other equipment of the same type.

The Offeror shall submit costs for training to be conducted at the factory or at the Purchaser's location.

Training and instruction for the load control system and equipment shall be provided for the Purchaser's maintenance personnel to enable them to become familiar with the equipment supplied by the Contractor. In addition, the Contractor shall furnish educational material for dissemination to customers, covering the function and operation of equipment located on the customer premises. There shall be a maximum of _____ training sessions of _____ days each.

17.2 Classroom Training

The Offeror shall state in his proposal if factory training is available to Purchaser's personnel, and shall provide the curriculum cost of such training with his proposal.

17.3 On-the-Job Training

The successful Contractor shall provide on-the-job training (on an informal basis) for Purchaser's operating and service personnel in equipment operation and maintenance of the actual equipment installed. This on-the-job training shall be done concurrently with the installation and initial field testing of the communications system.

As part of his response, the Offeror shall state the number of personnel, and their qualifications as instructors that he will use to train, _____ radio technicians in the testing and maintenance of the equipment.

This on-the-job training shall include all of the communications equipment supplied under this specification.

18.0 MAINTENANCE AND MAINTENANCE RECORDS

The Contractor shall maintain the installed equipment from the time of equipment installation to the time of system acceptance. Maintenance shall be such as to maintain equipment to the performance levels as specified within.

If the Purchaser so elects, a maintenance contract shall be developed to extend maintenance for a period of one year from the date of system acceptance. During this period, the system shall be maintained at a level of performance as specified herein. At the termination of the first years contract, the Contractor shall conduct tests, set levels, and correct deficiencies as required to establish performance level of the system to the specifications contained herein. Test procedures as developed for the initial system tests shall be used and results documented.

Maintenance by the Contractor will be in accordance with these requirements:

- Replacement parts shall be at least of equal quality and ratings as the original parts
- Any water, oil, dust, or other foreign substance will be removed from the equipment, its parts and attachments
- Performance of the equipment will be kept at the level stated in the Purchaser's performance specifications
- Routine maintenance procedures prescribed or recommended by the Contractor for his equipment shall be followed
- The Contractor shall provide only factory trained and authorized maintenance personnel
- The Contractor shall supply comprehensive installation and maintenance manuals as part of this equipment purchase
- Service shall be provided on a 24-hour emergency call basis with on-site response within four hours after call

If there is any discrepancy between the maintenance obligations of the Contractor as represented by the standards of maintenance set out herein, the Contractor's Maintenance Agreement, the bid documents, or the proposal, the maintenance

obligations and standards most favorable to the Purchaser shall apply. The Contractor shall keep accurate records of all maintenance performed on each piece of equipment identified by serial number, including routine or preventive maintenance and emergency repairs, and shall make all records available for inspection by the Purchaser or his designee at any time upon reasonable request.

APPENDIX A

Radio Equipment Design Data

A. MICROWAVE EQUIPMENT

1. RF TRANSMITTER

a. Manufacturer's Model No.:_____.

b. Power Input:_____Vdc, _____ Amp, _____ Watts.

c. Guaranteed RF power output at input to antenna feed line:

Normal: _____ dbm
Standby:_____ dbm

d. Emission designator: _____.

e. Normal peak deviation: ± _____MHz.

f. Type of frequency reference element:_____

_____.

g. RF frequency stability: ± _____%.

h. Type of frequency control: _____.

i. Type RF power monitor:_____.

j. Is RF frequency monitored and alarmed?

Yes: _____ No: _____

k. Is RF power monitored and alarmed?

Yes: _____ No: _____

l. Data of spurious emission from waveguide:

_____ dbm vs. Frequency _____.

m. Data of spurious emission from equipment 3 feet away:

_____ dmb vs. Frequency _____.

n. Frequency of sensing pilot:_____MHz.

o. Power level of sensing pilot:_____dbm.

2. RF RECEIVER - Wideband (1850 - 1990 MHz)

a. Manufacturer's Model No.:_____.

b. RF preselection bandwidth (3 db pts.): _____ MHz.

c. Receiver selectivity at 60 db points: _____ MHz.

d. Receiver sensitivity for 58.5 dbrnco when noise loaded for 480

channels: _____.

e. Attach a graph showing the per-channel weighted noise (dbrnco) for the worst 3-KHz slot, with deviation adjusted as proposed in Bidder's calculations.

f. Receiver noise level (AM threshold): _____ dbm.

g. Squelch level - S/N (flat weighted): _____ db.

h. Squelch level - S/N (adjustment): _____ db to _____ db

i. RF channel output level for specified deviation: _____ dbm.

j. Maximum local oscillator drift without AFC: _____ %.

k. Brief description of AFC operation: _____

_____.

l. Are devices incorporated in the receivers to prevent the AFC from "locking" on spurious or undesired signals?

Yes: _____ No: _____

m. If center frequency: _____ MHz.

n. If bandwidth (3 db pts.) available:

_____ MHz _____ Channels

_____ MHz _____ Channels

_____ MHz _____ Channels

_____ MHz _____ Channels

o. Image Rejection _____ db

p. Brief description of receiver sensing _____

_____.

q. Frequency of sensing pilot: _____ MHz.

r. Power level of sensing pilot: _____dbm.

s. Description of local oscillator circuit:_____

_____.

B. MULTIPLEX CHANNELS

1. Channel bandwidth: _____KHz.

2. Type of modulation: _____.

3. Baseband spectrum from _____ to _____MHz.

4. Frequency stability: _____Hz.

5. Intelligible Channel Crosstalk:_____db.

6. VF Input impedance: _____Ohms.

7. VF Output impedance: _____Ohms.

8. Audio input level: _____dbm.

   Adjustable _____dbm to _____dbm

9. Audio output level: _____dbm.

   Adjustable _____dbm to _____dbm

10. Type of signaling _____.

    Freq._____ Level _____ dbmo

11. Frequency plan (Attach on a separate sheet).

12. Frequency response in db referenced to 1000 Hz.

    a. 300 - 3400 Hz = _____ $\pm$ db

    b. 400 - 3000 Hz = _____ $\pm$ db

13. Channel distortion: _____%.

    a. Test Tone: Level _____dbmo.

    b. Frequency _____Hz.

14. Return Loss: VF _____db.

    Frequency range _____Hz.

15. Degree of limiting: _____ dbmo.

16. Back to Back: Unfaded channel noise _____ dbrnco.

a. Idle Noise _____ dbrnco.

b. Channel Loading per _____

Channels _____ dbrnco.

c. Data loading at -8 dbmo/Channel

Channels _____ dbrnco.

Channels _____ dbrnco.

Channels _____ dbrnco.

Channels _____ dbrnco.

17. Pilot frequency (if used) _____ KHz.

18. Carrier leak: On-hook _____ dbmo.

Off-hook _____ dbmo.

19. Envelope delay distortion:

_____ to _____ KHz _____ Microseconds

_____ to _____ KHz _____ Microseconds

_____ to _____ KHz _____ Microseconds

_____ to _____ KHz _____ Microseconds

_____ to _____ KHz _____ Microseconds

_____ to _____ KHz _____ Microseconds

20. Drop Level stability:

Period: 1 Month _____ db

Period: 3 Month _____ db

C. SERVICE CHANNEL

1. Frequency Response 0.3-3 KHz referenced to

1 KHz: $\pm$ _____ db.

2. Unfaded channel SN ratio: _____db.

3. Channel bandwidth: _____KHz.

4. Type of modulation: _____.

5. Baseband spectrum: _____MHz.

6. Frequency stability: _____Hz.

7. Input impedance: _____Ohms.

8. Output impedance: _____Ohms.

9. Audio input level: _____dbm.

10. Audio output level: _____dbm.

11. Signaling frequency: _____Hz.

12. Baseband crosstalk: _____db.

13. Distortion: _____Headset _____%, Loudspeaker _____%.

14. Remote Audio Extension Possible: Yes_____ No _____

APPENDIX B

Site Survey and Data Summary Sheets

Site Name and Number_____

Latitude_____Longitude_____(Degrees, Min, Sec)

Map reference (most detailed topographic)_____

Nearest town (postoffice)_____

Access route: (all Year?)

Property owner; local contact:

Site sketch_____Site photograph_____General description_____

Reference baseline_____By Polaris_____Other_____

Antenna No. _____ True bearing_____

Ground elev. MSL_____Takeoff angle (beam centerline_____

Takeoff angles to 45° right and left of centerline_____
(Significant changes in horizon)

Critical Points: (include horizon)

Distance_____Map elev._____Survey elev._____

Tree height_____Required clearance_____

Description:

Horizon sketch_____Horizon photograph_____

Power availability:

a. Nearest transmission line_____ b. Voltage_____

c. Frequency_____ d. Phase_____e. Operating utility_____

Drinking water source_____Estimated depth to groundwater_____

Sewage disposal_____ Type and depth of soil on and near site_____

Nearest airport_____ railroad_____ highway_____

navigable river_____

Checklist for Site Survey (page 1 of 2)

Local communications facilities: telephone_____telegraph_____radio_____

Nearby radio transmitters_____relay stations_____

Other interference sources_____

Local transportation facilities: airlines_____railroads_____

truck_____bus_____

Warehouse and storage facilities_____

Local suppliers (hardware, lumber, concrete, etc.)_____

Local contractors_____

Fuel sources (oil, gas, propane)_____

Local housing accommodations: temporary_____permanent_____

Local military or civil contact_____

Meteorological data from local sources: (averages for each month)

Maximum/minimum temperature (daily) _____

Precipitation _____ (Also extreme 1- and 24-hour)

Snow depth _____ (Also maximum for period of record)

Prevailing wind direction and speed_____

Extreme wind gust and direction_____

Dewpoint or relative humidity (mean diurnal change) _____.

DATE:	OBSERVER:
SITE NAME and NUMBER:	
LOCATION: Section Town Range County State Country	
REFERENCE MAPS:	
DESCRIPTION:	
ACCESS ROUTE:	
SITE LOCATION SKETCH (not necessarily to scale)	

Site Information Worksheet

A. Distance on Profile _____ km.

Ground Elevation _____ m above m.s.l.

Tree or Obstacle Height _____ m above ground.

Total Obstruction Height _____ m above m.s.l.

For an assumed upper antenna height of _____ m, clearance of

_____ m is realized for "k" = _____ (worst case). This provides

_____ (fraction) of _____ (order) Fresnel Zone clearance for this "k" value.

B. Distance on Profile _____ km.

Ground Elevation _____ m above m.s.l.

Tree or Obstacle Height _____ m above ground.

Total Obstruction Height _____ m above m.s.l.

For an assumed upper antenna height of _____ m, clearance of

_____ m is realized for "k" = _____ (worst case). This provides

_____ (fraction) of _____ (order) Fresnel Zone clearance for this "k" value.

C. Distance on Profile _____ km.

Ground Elevation _____ m above m.s.l.

Tree or Obstacle Height _____ m above ground.

Total Obstruction Height _____ m above m.s.l.

For an assumed upper antenna height of _____ m, clearance of

_____ m is realized for "k" = _____ (worst case). This provides

_____ (fraction) of _____ (order) Fresnel Zone clearance for this "k" value.

Link Design Clearance Check

Site Name & Antenna Designation	Site & Antenna Abbreviation	Latitude	Longitude	Tower Base Elevation above m.s.l. (m)

Worksheet Site Location Summary

Antenna Ident. No.	Site	Path	Pointing Azimuth from True North	Height above Ground (m)	Frequency (GHz)	Polari-zation (V or H)	Type	Diameter (ft)	Antenna Gain (dBi)	Beamwidth (degrees)	Function (Rx or Tx)

Worksheet Antenna Information Summary

APPENDIX C

Link Data/Design Summary Worksheets

Current and future channel requirements for traffic

from site_____ to site_____.

Type of Channel	Number of Channels	Baseband per Channel	Quality	Equivalent voice channels per information channel	Number of equivalent voice channels	Baseband Spectrum
Voice (Telephone)						
Voice (Facsimile)						
Voice (Low Speed Data)						
Voice (Medium Speed Data)						
Digital Data (High Speed)						
Video						

Totals _____ _____

Link channel requirements rounded to the next higher nominal value _____

Transmitter RF bandwidth _____

(Future Expansion)

Voice (Telephone)						
Voice (Facsimile)						
Voice (low Speed Data)						
Voice (Medium Speed Data)						
Digital Data (High Speed)						
Video						

Site Identification

(1)_____, _____ (2)_____, _____
(Name) (Abbreviation) (Name) (Abbreviation)

Site Location and Physical Parameters

(3) Latitude____ ____ ____ ____ (4) Latitude____ ____ ____ ____

(5) Longitude____ ____ ____ ____ (6) Longitude____ ____ ____ ____

(7) Altitude above mean sea level_____m. (8) Altitude above mean sea level_____m.

(9) UTM Coord._____ (10) UTM Coord. _____

(11) Azimuth to (2), ____ ____ ____ True (12) Azimuth to (1), ____ ____ ____ True

(13) Proposed upper antenna height above (7),_____m. (14) Proposed upper antenna height above (8),_____m.

(15) Proposed vertical diversity antenna separation from (13), _____m. (16) Proposed vertical diversity antenna separation from (14), _____m.

(17) Proposed antenna type, _____ (18) Proposed antenna type, _____

(19) Size_____ft, _____m (20) Size_____ft, _____m

(21) Expected antenna gain _____dB above isotropic (22) Expected antenna gain _____dB above isotropic

(23) Design center carrier frequency _____GHz. (24) Receiver noise threshold $-174 + 10 \log B_{IF} + F$ _____dBm.

Link Design Summary

(25) Required waveguide length, _____m.

(26) Required waveguide length, _____m.

(27) Proposed waveguide type _____

(28) Proposed waveguide type _____

(29) Waveguide loss per standard length ____dB per _____m

(30) Waveguide loss per standard length ____dB per_____m

(31) Waveguide loss $A_{t\ell}$ _____dB (including connectors)

(32) Waveguide loss $A_{t\ell}$ _____db (including connectors)

(33) Circulator and/or Diplexer Losses A_c

Transmit_____dB

(34) Circulator and/or Diplexer Losses A_c

Receive_____dB

(35) Isolator Losses A: Transmit _____dB

(36) Isolator Losses A: Receive _____dB

(37) Net fixed losses, (31) + (32) + (33) + (34) + (35) + (36), _____dB.

(38) Proposed transmitter power ____ watts, _____dBm.

(39) Path length _____ km.

(40) Free space basic transmission loss, L_{bf}, _____dB.

(41) Atmospheric absorption, A_a, _____dB.

(42) Net loss, (37) + (40) + (41),_____dB.

(43) Net gain (21) + (22) + (38) (dBm)_____dBm.

(44) Expected median receiver input power, P_r, (43) - (42) _____dBm.

(45) Order of diversity used_____.

(46) Type of diversity combiner used_____.

(47) Rain rate zone _____

Link Design Summary.

1	Number of equivalent voice channels, n	_____		
2	Voice channel bandwidth, b_c	3100 Hz	(Usable bandwidth)	
3	Maximum modulating frequency, f_m	_____kHz		
4	Baseband bandwidth, B_b	_____kHz	$B_b = f_m - f_\ell$, where f_ℓ is the lowest frequency in baseband	
5	RMS load factor, LF	_____dBm0	-10 + 10 log n	
6	Numerical RMS load factor ℓf	_____	antilog(LF/20)	
7	Peak factor, PF	13.5 dB		
8	Numerical peak factor, pf	4.73	antilog(PF/20)	
9	RMS per channel deviation, δf	_____kHz		
10	RMS carrier deviation, δF	_____kHz	δF = (ℓf)(δf)	
11	Peak carrier deviation, ΔF	_____kHz	ΔF = (pf)(ℓf)(δf)	
12	Receiver IF bandwidth, B_{IF}	_____kHz	$B_{IF} = 2(\Delta F + f_m)$	
13	Receiver noise figure, F	_____dB		
14	Receiver noise threshold	-_____dBm	-174 + 10 log B_{IF}(Hz) + F	
15	FM improvement threshold	-_____dBm	-174 + 10 log B_{IF}(Hz) + F + 10	
16	Pre-emphasis improvement, I_p	4 dB		
17	Median diversity improvement, I_d	_____dB		
18	Radio set NPR	_____dB		

Worksheet Basic Parameters for Median Noise Calculations

1	Transmission line or waveguide length, transmitter	_____m	
	Type of transmission line or waveguide	_____	
2	Percent velocity of propagation	_____%v	
3	Velocity of propagation, v	_____m/sec	$v = (3 \times 10^{8})\ (\%v \times 10^{-2})$
4	Echo delay time,	_____sec	$\tau \approx 2L/v$
5	Radian delay	_____rad	$2\pi f_m \tau$
6	Parameter A	_____	$A = \delta F/f_m$
7	S/D - r	_____dB	
8	Transmit system		
	Antenna return loss	RL_{ANT} _____dB	
	RF interface return loss	RL_{RFI} _____dB	
9	Echo amplitude, r	_____dB	$r = RL_{ANT} + RL_{RFI} + 2A_{t\ell}$
10	Transmit signal-to-distortion ratio, S/D	_____dB	$S/D = (S/D - r) + r$
11	Transmit signal-to-feeder echo noise, S/N_f	_____dB	$S/N_f = S/D + 10 \log \frac{B_b}{b_c} - L_F$
12	Transmit feeder echo noise, $N_{f(trans.)}$	_____pW0	$N_f = \text{antilog} \frac{90 - S/N_f}{10}$

Worksheet Transmitter Feeder Echo Noise Calculation

1	Transmission line or waveguide length, receiver		_____ m	
	Type of line or waveguide		_____	
2	Percent velocity of propagation		_____ %v	
3	Velocity of propagation, v		_____ m/sec	$v = (3 \times 10^{8})\ (\%v \times 10^{-2})$
4	Echo delay time, τ		_____ sec	$\tau = 2L/v$
5	Radian delay		_____ rad	$2\pi f_m \tau$
6	Parameter A		_____	$A = \delta F/f_m$
7	S/D - r		_____ dB	
8	Receive system			
	Antenna return loss	RL_{ANT}	_____ dB	
	RF interface return loss	RL_{RFI}	_____ dB	
9	Echo amplitude, r		_____ dB	$r = RL_{ANT} + RL_{RFI} + 2A_{t\ell}$
10	Receive signal-to-distortion ratio, S/D		_____ dB	$S/D = (S/D - r) + r$
11	Receive signal-to-feeder echo noise, S/N_f		_____ dB	$S/N_f = S/D + 10 \log \frac{B_b}{b_c} - LF$
12	Receive feeder echo noise, $N_{f(receive)}$		_____ pW0	$N_f = \text{antilog} \frac{90 - S/N_f}{10}$

Worksheet Receiver Feeder Echo Noise Calculation

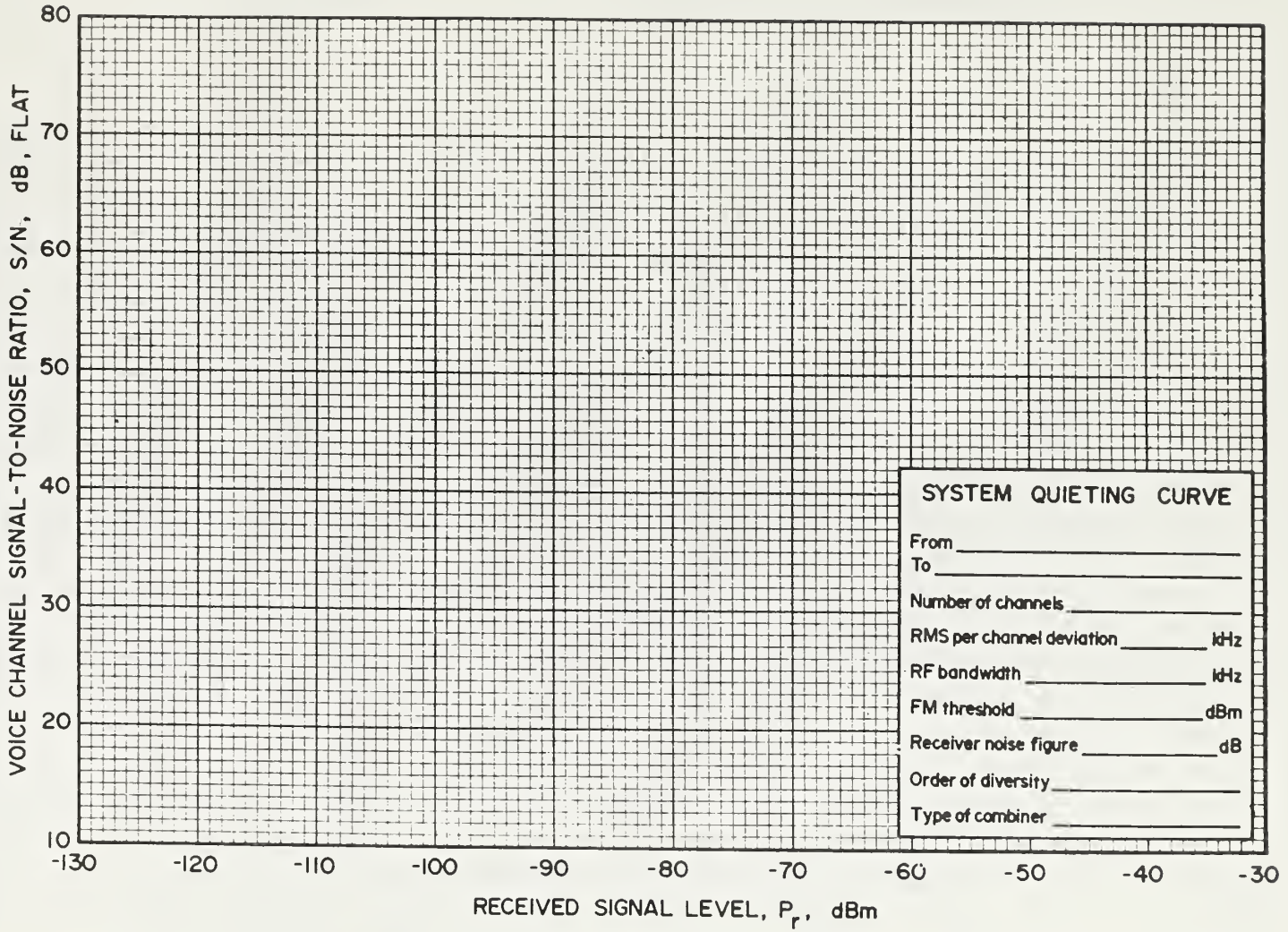
1	Total feeder echo noise, N_f	_____	pW0	$N_f = N_{f(trans)} + N_{f(receive)}$
2	Signal/equipment intermodulation, S/N_e	_____	dB	$S/N_e = NPR + 10 \log \frac{B_b}{b_c} - LF$
3	Equipment intermodulation noise, N_e	_____	pW0	$N_e = \text{antilog} \frac{90 - S/N_e}{10}$
4	Calculate $20 \log \frac{\delta f}{f_m}$	_____	dB	
5	Calculate $10 \log KTb_c + F$	_____	dBm	$-139.1 + F$
6	Signal-to-thermal noise ratio minus received signal level, $S/N_t - P_r$	_____	dB	$S/N_t - P_r = -10 \log KTb_c - F + 20 \log (\delta f/f_m)$
7	Draw quieting curve on worksheet			
8	$P_r(0.5) = (P_r - 3\ dB)$	_____	dBm	
9	Median signal-to-thermal noise ratio, $S/N_t(0.5)$	_____	dB	$(S/N_t - P_r) + P_r(0.5)$
10	Median thermal noise, $N_t(0.5)$	_____	pW0	$N_t(0.5) = \text{antilog} \frac{90 - S/N_t(0.5)}{10}$
11	Emphasis-improved signal-to-thermal noise ratio, $S/N_{te}(0.5)$	_____	dB	$S/N_{te}(0.5) = S/N_t(0.5) + I_p$
12	Emphasis-improved thermal noise, $N_{te}(0.5)$	_____	pW0	$N_{te}(0.5) = \text{antilog} \frac{90 - S/N_{te}(0.5)}{10}$
13	Total median noise, $N_T(0.5)$	_____	pW0	$N_T(0.5) = N_{te}(0.5) + N_f + N_e$

Note: Median values are denoted by (0.5).

Worksheet Calculate Median Total Noise Performance

Worksheet Path Parameter Summary

No.	Path	Profile No.	Tower Base Elevation above m. s. l. (m)	Tower Height (m)	Distance (km)	Frequency (GHz)	Free Space Basic Transmission Loss(dB)	Feeder Length (m)	Filter & Feeder Loss (dB)	Total Loss (dB)	Antenna Size (feet)	Passive Reflector Size (ft)	Highest Antenna or Reflector Height above Ground (m)	Antenna Gain, dB above Isotropic	Net Path Loss (dB)	Transmit Power (dBm)	Median Received Carrier Level (dBm)	IF Bandwidth (MHz)	Receiver Noise Figure (dB)	KTBF (dBm)	C/N (dB)			



Worksheet Graph for System Quieting Curve

No.	Path	Terminal	No. of Channels	Hop Time Availability (Percentile)	C/N Front End (dB)	Highest BB Frequency (MHz)	Fade Margin (dB)	Diversity Improvement (dB)	Top Channel Noise Power, Unweighted (picowatts)					Total Channel S/N, flat, (dB)				Percent of Time Hop Exceeds 10⁵ pW0 (flat)	Noise Allocation
									Thermal	Intermod-ulation	Feeder Echo	Emphasis-Improved Thermal	Total						
TOTALS																			

Worksheet System/Hop Noise Allocation

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